DISCOVERY

THE MAGAZINE OF SCIENTIFIC PROGRESS

MARCH 1959 2/6

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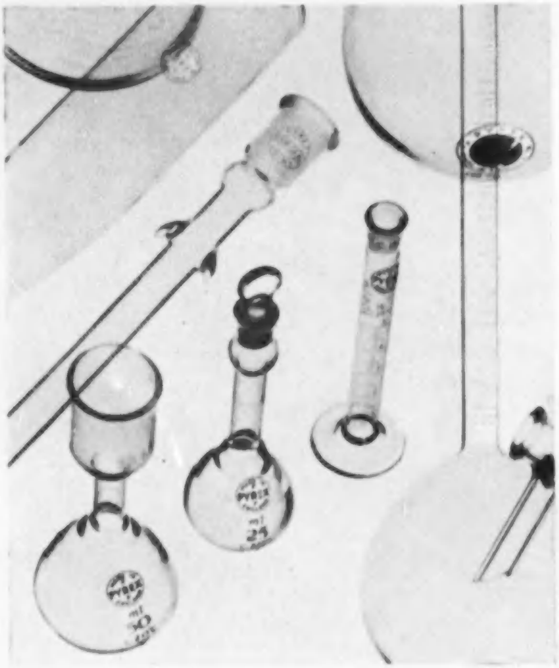

—and measuring is more than a question of millimetres and millilitres, when you actually have the flask in your hand or the measuring cylinder before you on the bench. Will it, for instance, wash? Will it wobble or joggle? If it fell over, what are its chances? Will it *sterilize*? When it's PYREX, you needn't waste time asking these questions; for you know everything has been thought of, planned for, carefully checked. That is true of everything in the PYREX range. Small wonder that so many people with scientific work to do demand PYREX

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DISCOVERY

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OUR COVER PICTURE

(See the articles on p. 110), the results of a government survey on the reading habits of scientists.

CONTENTS

Seeing

is believing . . .

Old sayings, it might be supposed, have no place in the ordered, logical world of science. Yet wherever research is concerned with phenomena outside the normal limits of human perception, the reliance placed by scientists on photographic methods of rendering visible the "invisible" bears out the essential truth expressed in "seeing is believing".

The pioneers of photography (scientists too in their own right) might nevertheless find it hard to believe their own eyes were they to be confronted with some of the results of modern scientific photography—but they could not fail to recognise the amazing progress in manufacturing technique which has enabled Ilford sensitised materials to play a leading role in so many aspects of present-day research.

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THE PROGRESS OF SCIENCE

SCIENCE AND INDUSTRY

> ". . . a very large aggregate of smaller English businesses is carried on in a stupidly conservative fashion with antiquated machinery, traditional modes of conduct and methods which ignore the scientific advance of recent years."

Though this quotation may seem familiar, how many of our readers in fact realise that it comes from a leading article in *The Times* of November 28, 1902, about a visit by a productivity team of twenty-three British Trade Union officials to the United States of America. We would naturally prefer to think that the lessons of over fifty years ago have been absorbed and acted upon. Unhappily, *plus ça change, plus c'est la même chose*, and the publication in January 1959 by the DSIR of its "Estimates of Resources Devoted to Scientific and Engineering Research and Development in British Industry, 1955" appears to confirm many of the fears which DISCOVERY has constantly expressed. Despite DSIR's natural cautiousness of presentation, the foreword concedes that "the contrasts between the ratios of expediture and research and development to turnover and net output in some of the science-based industries on the one hand, and in some of the more traditional small-scale industries on the other hand, clearly raises questions of great importance".

Like liberty, the price of scientific progress is eternal vigilance. The crucial question is not one of "keeping up with" the U.S.S.R. or the U.S.A. in the race for scientific leadership, but of understanding the nature of this scientific challenge—that the impact of accelerated technological change must have far-reaching effects on the character and structure of industry if it is to be implemented. Thus, by way of illustration, it has been estimated that in the U.S. today, half the labour force is engaged in producing and selling goods which were unknown fifty years ago, and that if this trend continues, half the working population will, twenty-five years hence, be similarly concerned with products as yet unknown. For Britain, which must compete in swiftly changing world export markets, this is a major test, both of our industrial adaptability in the widest sense, and in particular of our ability to apply research increasingly and rapidly. Indeed, there is the danger that we may fall between two stools: a strong purposive drive for scientific development directed from the centre and matched with adequate resources, as in the U.S.S.R., for example; or the more competitive conditions of the U.S.A., Western Germany, or Switzerland, where scientific innovation is an essential condition for the economic survival of many firms.

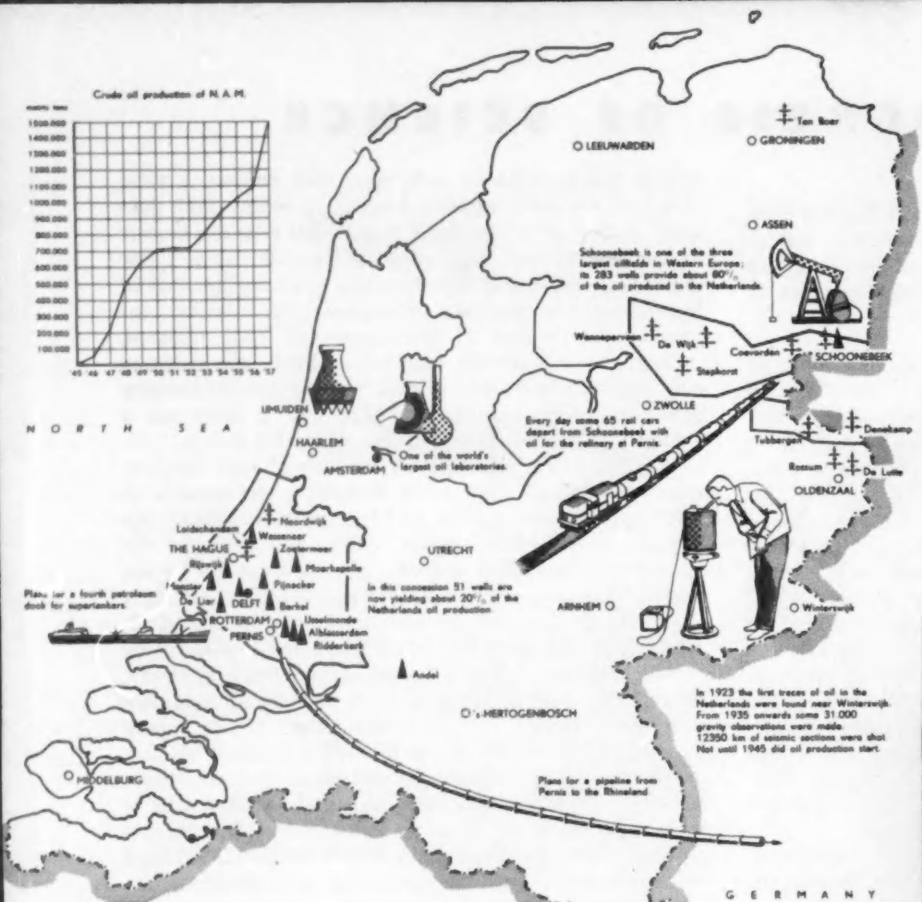
The facts speak for themselves. In 1955 the United Kingdom spent on research and development £300 million, or 1·6% of the national product; the U.S.A. spent about $9 billion, 2·1% of a larger national product. State outlay notably for defence (and much of it through private industry) was an important element in both totals. But State finance for civil research has a particular importance for Britain, the most significant point being that in the U.S.A. private industry spent over $3 billion of its own resources—0·75% of the gross national product—and in Britain private industry only spent £68 million, a mere 0·36% of the gross national product. It seems more than likely in the light of the DSIR Report that even this modest expenditure by private industry is concentrated in a few scientifically advanced industries and in a small number of large companies or groups. Recognising the valuable contribution in Britain of State-sponsored civil research, including co-operatively financed research, the question may legitimately be put: should not our private industry spend more on scientific research, and is there not a tendency to rely passively on State-supported activity?

That there are difficulties in the way of such developments is to be allowed. Lord Monckton, for instance, at last year's British Institute of Management's annual conference, spoke of the stakes being "too high for the management to venture at their own discretion and for the shareholders to approve if it were practicable to seek their opinion". In *The Observer* last November, Mr. Shonfield, referring to the development of electronic computers by private industry, wrote: "I call these firms gamblers, because they habitually spend more on research than they distribute in profits. . . ." Such observations may be cogent, but they are not arguments *against* inducing private industry to spend more of its own resources on research, but arguments *favouring* a much closer study and understanding of the inter-relation of scientific innovation and economic processes. History indeed abounds in examples of the ideal industrial combination, the partnership of the inquiring and enterprising business man, and the scientist, pure and applied.

In contrast, if one is to explain inadequate scientific development over wide tracts of British industry today, it must be, as empirical evidence bears out, in terms of the "backward" firm. How these numerous backward firms may be advanced is a question of infinite complexity. Part of the answer must be sought in the fields of sociology and education. For instance, in Switzerland, where small firms have not written off the march of science, there are most intimate links between industry generally and the universities, and it has been authoritatively observed that "most Swiss appear to have a respect for both learning and money-making". To bring about the correct *rapport* in British industry requires not merely a growing scientific manpower, but more education generally and a more broadly based one at that. For the challenge which science poses to British industry today is not merely a task for a few managers and technicians, but for all our working population, our institutions, and for society as a whole.

Important though the utmost use of science in industry is, one issue is of vital urgency for the whole of mankind—The Internationalisation of Space, and of Space Research. How near and yet how far we are to this through the UN is clearly shown by the report of the great debate at the end of last year (see p. 106). Scientific and political leaders of all nations must now create the International Space Research Institute, and they must formulate a Law of Space; COSPAR must become executive and not merely advisory. This issue is vital for the future of all mankind. *Caelum Commune!*

OIL PIPELINE FROM ROTTERDAM TO THE RHINE



Western Europe, in contrast to the United States of America, has few transcontinental pipelines. The only pipelines—outside the NATO lines—now in operation in this part of the world are first, the one which carries oil products from the refineries in the Paris region to the port of Le Havre, and second, a 25-mile crude-oil supply-line in the province of South Holland. However, as refineries are moving away from the sea coast towards inland consumption areas, more pipelines will be needed. A 190-mile steel artery will have linked the Rotterdam harbour basins and the West German Rhineland by the middle of 1960.

While the production of coal remains pretty well constant over a period of years, water power is available only in restricted measure, and nuclear energy cannot yet be produced in commercial quantities, oil helps to meet the rapidly increasing demand for energy in the whole Rhine basin. Home production of oil in these countries, which in a few years has risen to a yearly amount of nearly 4 million metric tons in West Germany and to 1·5 million metric tons in the Netherlands, is still not nearly able to meet the requirements.

Rotterdam plays a leading part in the import of crude oil from the Middle East and Venezuela—to name only two sources. Of the 74·1 million tons of goods handled in 1957 by the port, 30 million tons were in the form of oil and oil products. Two refineries downstream from Rotterdam process a major portion of the several crudes, dealing with about 15 million tons a year. Of these, 12·5 million tons were processed by Shell and 2·5 million by Caltex.

As from 1946 a tank-farm is being built on a part of the site of the Shell refinery at Pernis, which lies half-way between Rotterdam and The Hook on the south bank of the Maas. Part of this tank-farm is intended for storing crude oil, which will be processed in refineries in the West German industrial area.

Caltex will also receive oil from abroad in this way in its own tanks and the two companies, together with the Gelsenberg & Mobil Öe Handels- und Transport-Gesellschaft m.b.H., will use the pipeline now under construction to convey crude oil eastwards; initially 7·5 million tons per annum will be transported, rising to a maximum of 20 million tons—independent of weather conditions.

The pipeline seen from the shore.

Crossing a road in the neighbourhood of Rhoon.

Last summer a combine of Dutch and German contractors, assisted by American experts, started laying the pipeline, with a diameter of 24 in. (roughly 60 cm.), which will have a ground shelter of at least 60 cm. throughout its length.

The N.V. Rotterdam-Rijn Pijpleiding Maatschappij was founded on April 3, 1958. The first sections of piping were brought from Germany to the port of Maassluis at the beginning of July. The pipes are given anti-corrosive wrappings, are welded together along the route and, with additional cathodic protection, laid in a trench and covered with earth. In September 1958, 2000 yds. of pipeline had been laid across the bottom of the Hollands Diep

On its way, the Rotterdam-Rhine pipeline will have to cross not only rivers but also numerous dykes, roads, and railways. To do this, a method which consists of boring an opening through which a "casing pipe" is pushed will be used. Sections of the pipeline are placed inside this casing pipe.

The pipeline will pass over about 100 miles of Dutch territory. The route runs south-eastwards from Pernis across IJsselmonde and Beijerland to the Moerdijk. From there it runs in an almost straight line to a point north of Venlo; negotiations on the routeing of the two branches on German territory are now about to be completed. The whole system will be ready for use by the middle of 1960.

The three partners intend to use the pipeline for supplying crude oil to the existing refinery of the Gelsenberg Benzin A.G. at Gelsenkirchen, to the refinery of the Deutsche Shell A.G. at Godorf, near Cologne, which is now under construction, and to the Caltex Tankkraft A.G., also near Cologne.

At the moment laden tankers of up to 45,000 tons can berth in the first and second petroleum docks in Rotterdam, but a deepening of these basins is already on the programme. For berthing very big ships, however, it will be necessary to wait for the opening of the fourth petroleum dock, for which dredging operations have been started.

Work in progress in and around Rotterdam thus reflects the importance of oil to Western Europe, in which many thousands of people are concerned and without which a modern society cannot exist.

"BRIGHTER THAN A THOUSAND SUNS"

This book,* which was a sensational success in Germany and serialised in leading German newspapers, is now available in English. It is the story of the A- and H-bomb, but, it goes deeper than this, as is shown by its subtitle, "The Moral and Political History of the Atomic Scientists". It is an extremely readable book, written by a competent journalist in the "Pugwash" spirit; but it deals only with the achievements and failures of the West, as uncensored information from Soviet scientists was unobtainable. This gives to the latter half of the book an unavoidable lack of balance and of global perspective. The author acknowledges the help of thirty-three U.S., seventeen German—but only six British—physicists who have given him interviews, but himself accepts responsibility for the interpretation or reproduction of their statements. Unpublished files, dossiers, and correspondence were placed at his disposal.

Apparently most of the information about the German efforts was obtained from Heisenberg, von Weizsäcker, and Houtermans. The first two played a leading part. Heisenberg, strongly influenced by the brilliant and diplomatic von Weizsäcker and the ambitious Wirtz, was the scientific leader of the team. Houtermans never played a role in the "inner circle", although Jungk's book claims that he foresaw the generation of "explosive" transuranic elements in a uranium pile, and also in 1932 in Russia called attention to the possibility of a chain reaction. The suggestion that, had Houtermans not been imprisoned by the Russians, fission and chain reaction might well have been discovered in Russia seems to the present reviewer too far-reaching a claim even for such an able physicist.

Dr Jungk attributes the German failure to construct an A-bomb to four factors:

1. Absence of the eminent physicists who left Germany to escape the gas chamber. This undoubtedly was an important factor, and a few names such as Frisch, Peierls, Paneth, Simon, Szilard, Wigner, Teller sufficiently prove this point.

2. Poor organisation of Nazi research. Also correct; the exact sciences, especially physics and mathematics, were suspect. Acceptance of Nobel prizes was banned (for the next 1000 years!). Only two small cyclotrons were just about workable by 1945, but an x-ray crystallographer quite earnestly suggested fighting enemy aircraft by the use of beams of energetic electrons to produce high-energy penetrating x-rays.

3. Lack of technical and industrial resources, and the limited capacity of German industry. This was another important factor, particularly in view of the increasing Allied bomber offensives.

4. In Dr Jungk's words, "the actual personal attitude of the German experts in atomic research . . . [who] . . . were able successfully to divert the minds of National Socialist Service departments from the idea of so inhuman a weapon". This will be referred to later.

A fifth and more important factor is omitted: the Germans knew that in principle a bomb *could* be made; they had no idea *how*. A detailed theory of the A-bomb had never been developed in Germany and the concentration and separation of U235 was more or less unsuccessfully tried by several methods until nearly the end of the war. The maximum enrichment of U235 obtained was about 5%. The successful method, by which pure U235 was obtained at Oak Ridge, was the gaseous diffusion method which, by the introduction of the cascade principle, had been developed in 1932 by Hertz, in Germany. This was never tried by the Germans.

As far as the reviewer is aware, no member of the German U-team has admitted this ignorance of how to prepare a bomb. They regarded the production of energy from a reactor as a 10–15-year project and the construction of a bomb was envisaged in not less than 50 years. There are numerous proofs that they were quite ignorant of how to set about the construction of an A-bomb, and one is provided by the very open diary of Bagge, a member of the U-team who after the war was detained in England with other German physicists. He describes vividly their reactions and remarks after hearing on the wireless the first news of Hiroshima. They were incredulous, hazarding guesses as to its real nature—probably a mixture of atomic hydrogen and oxygen, and so on. Only two, one of them Diebner of the Army Weapons Department, admitted the possibility of a real A-bomb. There were records made, unknown to them, of all their conversations during this period of internment. Heisenberg's statement, in 1946, that "external circumstances" had relieved the German atomic experts from the need "to take the difficult decision whether or not to produce atom bombs" may be regarded as correct—if ignorance of how to do so is taken to be synonymous with "external circumstances".

A fundamental question therefore arises. Was it really true that research was directed towards the controlled chain reaction in order to deprive Hitler of this inhuman weapon; or because nobody knew how to produce it? After all, this information about the possibility of a "uranium machine" was given to the Nazi Ministry of Science and Education by two physicists, and in April 1939 the "green light" was given by the Ministry for preparatory work to go ahead. The head of the Ministry's Department of Research, in his enthusiasm, even promised to make available the Army's artillery shooting range for a "test", and shortly afterwards a very able Austro-German physical chemist, who had once worked with Rutherford, informed the Army Weapons Department of the "possibility in principle of the release of a chain reaction in uranium", recommending its investigation by the German War Office.

Work on the bomb practically ceased after a meeting on June 6, 1942, which was attended by the German physicists and the newly appointed Minister of Munitions, Speer. By then the project had changed hands again and was controlled by Abraham Esau, head of the Reich's Research Council. No method had been found for separation of sufficient quantities of U235, and the still hypothetical formation of a fissionable transuranic element seemed to be possible only in a uranium pile. Some progress had, however, been made in the direction of an energy-producing atomic pile. Speer decided that further work on the bomb was not necessary, but that work on the "uranium machine" should continue. This, be it noted,

* Robert Jungk, "Brighter Than a Thousand Suns", Victor Gollancz Ltd, in association with Rupert Hart-Davis Ltd, 1958, 350 pp., 21*s*. *Reviewed by P. Rosbaud.*

was at a time when the German armies were making fast progress towards the Lower Volga, Rommel's troops were near the Egyptian frontier, and the turning-point had not been reached. The Nazis were confident that they had nearly won their war.

Certainly, there were a number of atomic physicists who would never have assisted the Nazis to attain such a goal, and it would be simple to name at least a dozen. But there were many others, highly intelligent, ambitious, and convinced Nazis. Would they have remained silent? There were equally good physicists who in their own fields had no conscientious scruples about developing the murderous V1 and V2, and who were working right up to the end of the war on the "American Rocket", which was to cross the Atlantic. Today, we are told by many of them, in books and interviews, that these little excursions were principally preparations for their real goal—space travel and exploration of the moon and planets.

Dr Jungk has, in all sincerity, tried to create an important archive of the dilemma of science and scientists, on both sides of the Atlantic. It is indeed necessary for the judgment of future generations that every file, written and spoken word, and all sources of information should be recorded. Yet out of the material emerges a strange picture in which it sometimes appears that the German physicists alone have no actual or moral guilt for the A-bomb.

And there is the other and quite fundamental question: Who *is* to blame for the A-bomb? The author seems to start from the preconceived view that everybody is discredited who has actively collaborated on the project. The unbiased reader will form his own opinion on this and also whether there was moral justification for dropping two bombs on a practically defeated enemy.

The book contains a vast quantity of information, some of it of unknown origin. If there are errors of detail, the main facts (as distinct from opinions and interpretations) are correct. Much of the book is depressing and it is impossible to understand the mentality of many individuals. Heisenberg's own version of his conversation with Niels Bohr in the autumn of 1941 is an example. His handling of this interview may seem to the reader less than laudable, and to contain obvious contradictions and inconsistencies.

Shocking to the reviewer, and largely unintelligible in motive, is von Weizsäcker's report in 1942 to the political authorities of discussions between "modern" and Nazi physicists—discussions which should have been beneath the dignity of physicists of Heisenberg's and von Weizsäcker's calibre, and which should never have taken place. The reason given was that it was effective and necessary as camouflage.

The author has drawn most of his information from American sources. The English role is often neglected or ignored (and with the picture he paints of pre-war Cambridge nobody could agree who knew it in Rutherford's day). The reviewer is not in a position to judge whether the characterisation and motives of the leading individuals in America during the war are true to life. The great number of scientists from this country and the Commonwealth who worked in the U.S. may sometimes differ in their opinions from those of the author.

The frightening part begins with the decision, taken against the warning of some scientists, to drop the two bombs. The results of pure research are taken over by those who "apply" them, and the picture emerging is the grim one of research everywhere becoming increasingly integrated with the State and directed towards the technological needs of mass destruction and suicide.

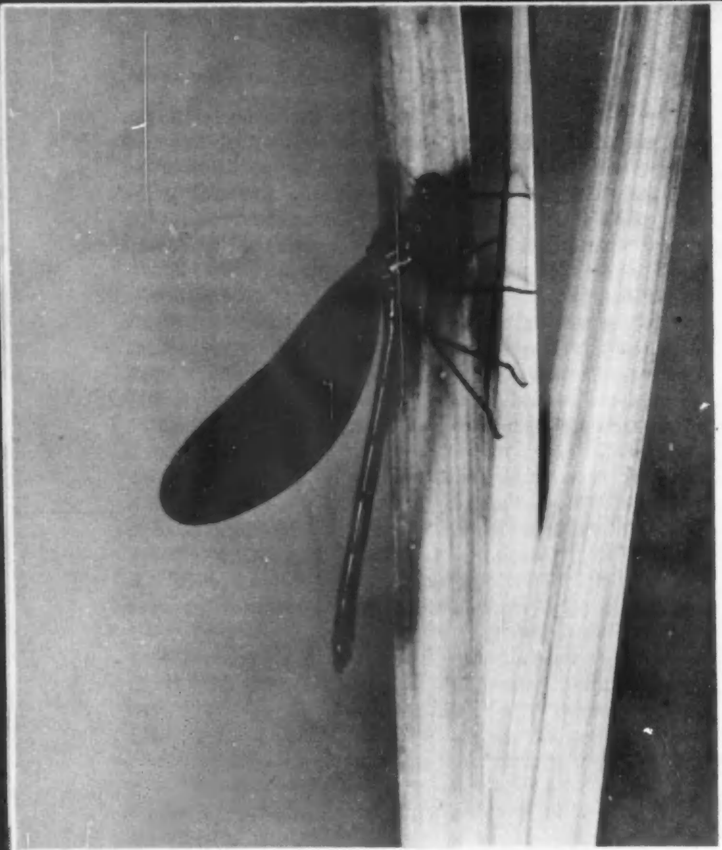
The A-bomb is followed by the "Super", the H-bomb, intercontinental ballistic missiles are developed—all this is superb physics—and every new weapon is more formidable than its precursor, and protection against these do not exist. The contamination of the whole planet through radioactive fall-out increases with every test explosion, but the reaction is often that "we have no proof of any danger" or, in its most dishonest form, that "the average life may, through the fall-out, be reduced by a quarter of an hour". If, in their public and published words men of science have to conform to the expediency of politicians, there is every danger that half-truths are uttered, "non-proven" is accepted as proof of its reverse, and that insincerity creeps into the work of scientists.

Dr Jungk has carried out his intention to report conversations, and record the information given him: he is not a scientist, living on the inside through the events described, and he was not in a position therefore to check from personal experience their accuracy; nor was it within his province to assess the veracity of his informants. It is of the utmost importance that the facts should be objectively on record for posterity. Unless humanity destroys itself, future generations should know not only these facts and their implications, but also what manner of men were involved and responsible for our present dilemma that they may judge. To this end, in new editions of his book, Dr. Jungk should receive the support of all those actively engaged on, or witnesses to, events which have brought the world to the edge of the abyss. Many corrections will have to be made, not mainly in matters of fact but in the faults of memory and interpretations of relationships, of which the "animosities" between Lise Meitner and Otto Hahn on the one side, and the Joliot-Curie group on the other is a clear example.

Rightly, the author does not venture to prophesy, but asks instead a challenging question. He leaves the reader to answer, and on that answer the whole future will depend. Dr Jungk has summed it up in a quotation from Wolfgang Pauli's lecture, "Science and Western Thought":

> "As against the strict division of the activities of the human spirit into separate departments since the 17th century, I regard the conceptual aim of overcoming the contrasts, an aim which includes a synthesis embracing the rational understanding as well as the mystic experience of oneness, as the expressed or unspoken mythos of our own present age."*

* "Entgegen der strengen Einteilung der Aktivitäten des menschlichen Geistes in getrennte Departmente seit dem 17. Jahrhundert, halte ich aber die Zielvorstellung einer Überwindung der Gegensätze, zu der auch eine sowohl das rationale Verstehen wie das mystische Einheitserlebnis umfassende Synthese gehört, für den ausgesprochenen oder unausgesprochenen Mythos unserer eigenen, heutigen Zeit."



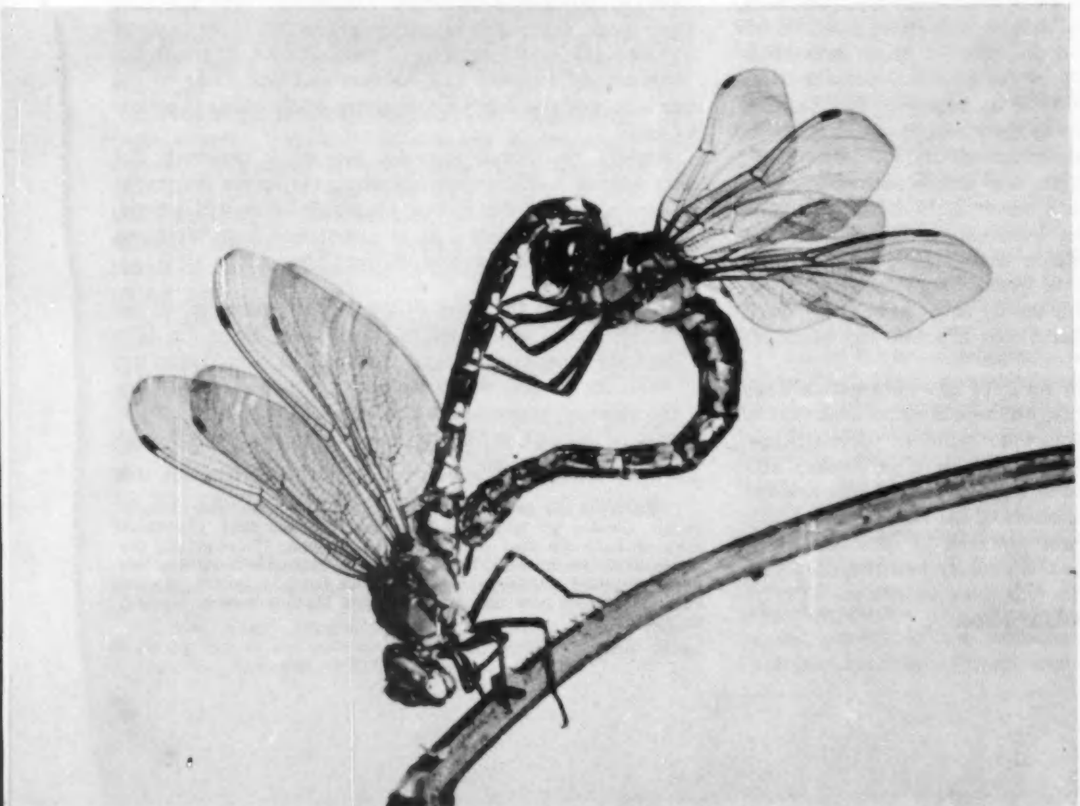
Male demoiselle dragonfly resting in typical position of all damsel-flies. (× 1¼ approx.)
(Photography by George E. Hyde)

THE BEHAVIOUR OF DRAGONFLIES

Because of their large size and flashing colours, dragonflies are a subject of interest to many who normally pay little attention to entomology. This has given rise to considerable speculation, and it is not surprising that the insects have figured in numerous legends and exaggerated accounts. The popular opinion that dragonflies can sting still persists, and the ancient name of "horse-stinger" is used in many places. So before going further it is as well to say that no dragonfly possesses a sting or is capable of harming a horse.

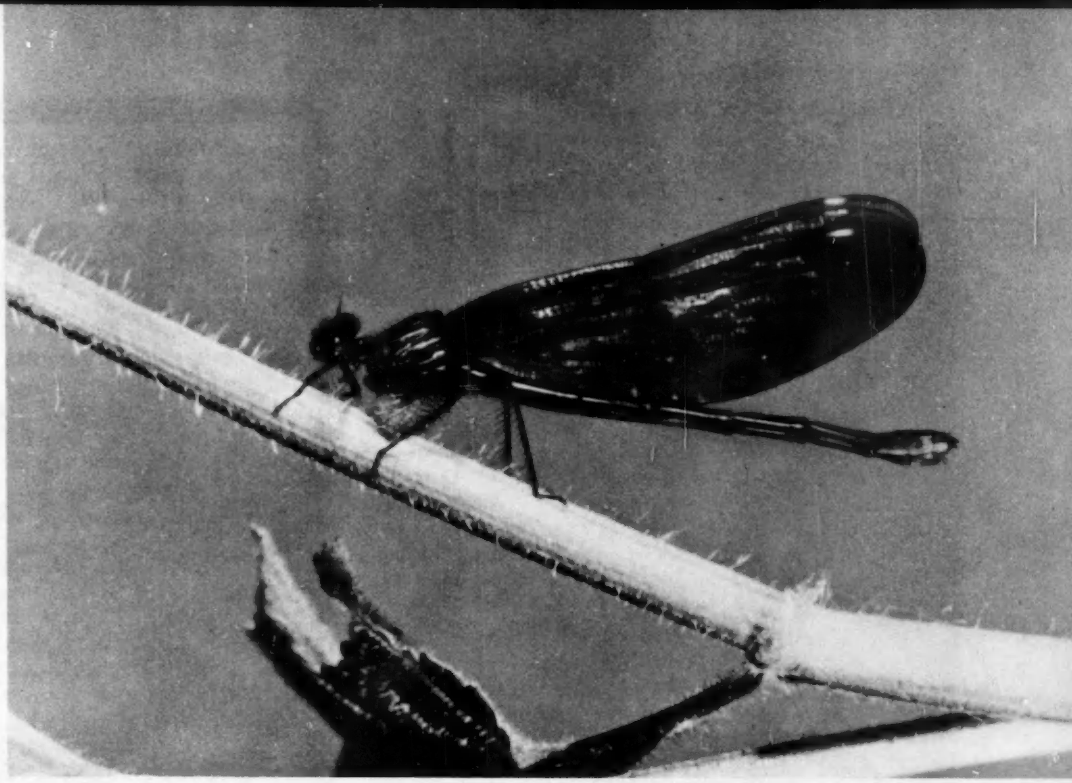
Dragonflies are completely diurnal, and sun-loving to the same extent as butterflies. They become very active in bright summer weather, but are usually inactive when the sky is overcast. At such times they rest on trees and plants where they are not so easily detected. If the dull weather persists they may remain immobile for several days, but no British dragonfly survives the winter. Entomologists refer to dragonflies as Odonata, and the name arises from the insects' possession of toothed jaws. These are used to capture and masticate small flies and other winged prey taken in flight. It will be appreciated that the habit separates dragonflies from the bulk of other insects, most of which have no biting jaws, and are incapable of taking solid food.

There are two large divisions of dragonflies, and these are known respectively as the Anisoptera and Zygoptera. The former includes the larger, more robust species commonly called hawkers, and the latter consists of the slender, slower-moving kinds known as damsel-flies. Anisoptera dragonflies always rest with the wings fully extended, but in the Zygoptera species the wings are folded together like the wings of a sleeping butterfly. It is useful to remember this.



A pair of aeshna dragonflies. The male is uppermost and is holding the female by the neck. (About natural size.)

A female demoiselle dragonfly at rest with the wings closed. (×2 approx.)

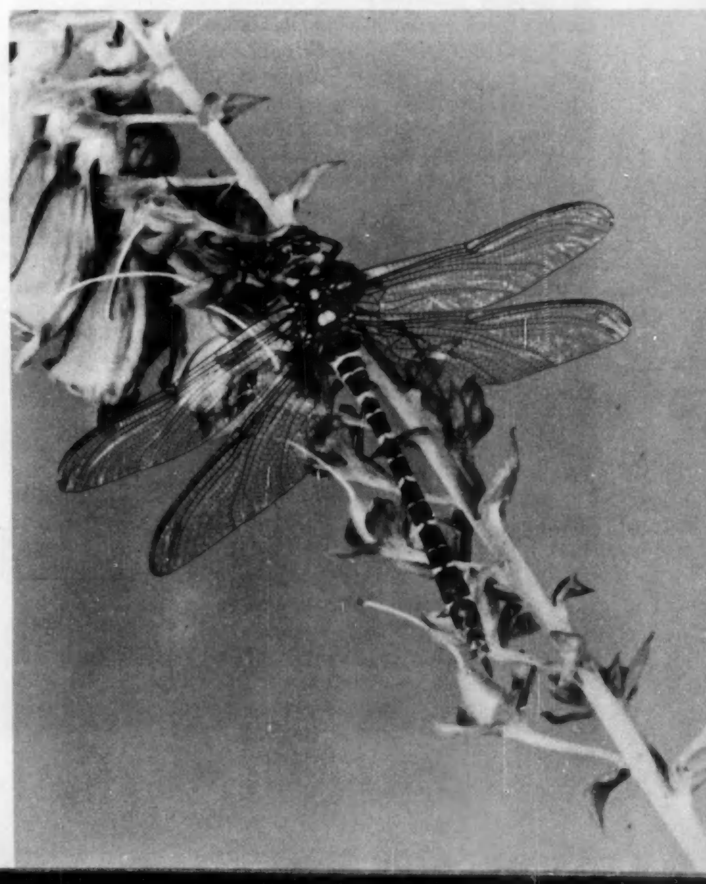


About forty species of dragonflies, including members of both groups, have been found in Britain, and about half of them are fairly common and widely distributed. To find the remainder demands both time and patience as well as considerable travelling. One or two species are now so rare and restricted that they may not survive here much longer. The chief reason for this is because of the destruction of their haunts largely due to drainage.

No account of dragonflies, however brief, would be complete without a reference to their amazing life-history, for in this respect they differ from all other insects. The larval period is entirely aquatic, and the larvae, or nymphs, live in ponds, ditches, or similar places, for a period varying from a few months to as much as two years. During this time they (the larvae) prey on various small water creatures, and periodically they change their skins. On completing growth they leave the water by climbing up a reed or some other convenient plant, and after a further short lapse the dragonflies emerge. It will be seen that there is no pupal stage, or in other words the perfect insects develop direct from the larvae. The process is known as an incomplete metamorphosis; butterflies, moths, and most other insects have a complete metamorphosis.

Anyone who watches a number of dragonflies cruising over a pond should see something of their courtship and mating habits. The male pursues the female, and finally seizes her by the neck or head. He retains a hold by means of two anal appendages, or claspers, and his mate presses back her head to tighten the grip. The female then curves her long abdomen underneath that of the male until contact is made with the latter's accessory genitalia situated below the fore part of the abdomen. In some species the male dragonfly continues to hold the female as she lays her eggs in the water. These vary in shape according to the species, and are of minute size.

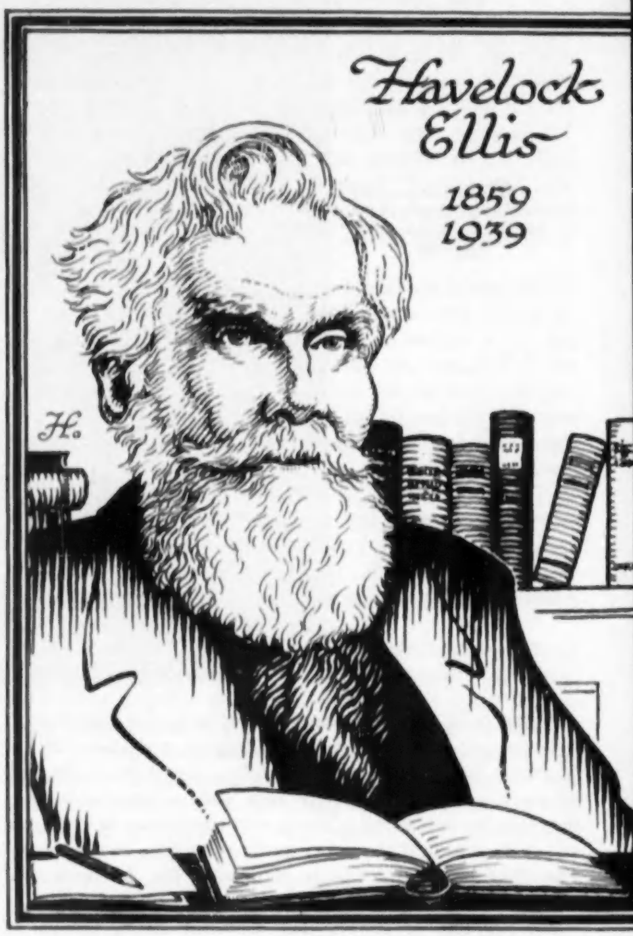
(*Below*) Golden-ringed hawker dragonfly resting on fox-glove plant. This species has a liking for running water. (About natural size.)



HAVELOCK ELLIS (1859–1939)

Essayist, editor, poet, artist, sociologist, philosopher, and pioneer in the study of the psychology of sex, who with fearless sincerity tore the veil of ignorance and prejudice from this subject, Henry Havelock Ellis was born at Croydon one hundred years ago, on February 2, 1859. He came into the world in the same year in which another immortal disturber of tradition, Charles Darwin, published the "Origin of Species", and he obeyed the omen. Descended on both sides of the family from seafarers, he spent much of his early life at sea. At the age of seven he accompanied his father, a captain in the Merchant Navy, on a trip round the world; some ten years later, developing severe abdominal pain which suggested a diagnosis of tuberculosis, he went on another long voyage to Australia, and from 1875 to 1879 taught in a school at Sydney. During a lonely adolescence he was greatly perturbed by moral and religious problems until he fell into the intellectual clutches of that bizarre man, James Hinton, mystic philosopher and sex pioneer. Hinton had studied medicine at St Bartholomew's Hospital and had qualified M.R.C.S. in 1847, but had treated science as the servant of philosophy. His young disciple likewise decided to take up medicine, not as a career, but as a biological foundation for his life's work. As a medical student at St Thomas's Hospital, he failed in surgery at the Conjoint examination and contented himself with the L.S.A. qualification in 1889. After practising for a short time at Harrogate and in Cornwall, he became editor of the *Contemporary Science Series*, for which he himself wrote "Man and Woman: A Study of Human Secondary Sexual Characters" (1894).

Ellis intended in the first place to study normal sex life and to investigate the abnormal manifestations only in so far as they illuminated the normal mechanism. Experimental work was then in its infancy, and his books represent vast collections of data gathered from science, anthropology, psychology, literature, and the arts, rather than experimentally verified facts. All his data, incidentally, were obtained through correspondence, for his shyness, which was almost pathological, forbade his direct access to clinical cases. The first volume of his "Studies in the Psychology of Sex", entitled "Sexual Inversion", was published in 1898, at a time when Oscar Wilde's trial was still a painful memory. On May 27 a disguised detective bought a copy from the bookseller George Bedborough, who, in October, was put up as a defendant, instead of the author, at the Old Bailey. Bedborough pleaded guilty, and the book was banned as being lewd, wicked, bawdy and obscene. It was then published in the United States and in Germany, and for a long time the only copies at the British Museum were in German. It is interesting to note that *The Lancet* refused to review this volume on the grounds that it was not published through a house "able to take proper measures for introducing it as a scientific book to a scientific audience . . . the book would fall into the hands of readers totally unable to derive benefit from it as a work of science and very ready to draw evil lessons from its necessarily disgusting passages". The final volume of "Studies in the Psychology of Sex" appeared in 1908. "His seven monumental volumes", according to *Archives of Neurology and Psychiatry* (1939, vol. 41, p. 804), "have probably served more than any other single work to bring sex out of the atmosphere of ignorance and prudery into the clear light of science, and will always remain an incomparable critical digest of the scientific knowledge of the subject up to contemporary times."



Havelock Ellis, a portrait specially drawn for DISCOVERY by Frank Horrabin.

Ellis was one of the first in England to draw attention to Freud's writings on psychopathology, but his insight into the significance of Freud's work remained a partial one.

Havelock Ellis's appearance harmonised with his character: he was a tall, thin man with a magnificent head, a patriarchal beard, and blue eyes. A scholar recluse, he seldom appeared in public, never lectured, and only rarely indulged in controversy. For many years he led a life of austere simplicity in Brixton, buying and preparing his own food. His literary style was lucid, elegant, witty, and full of infinite understanding. He died on July 8, 1939, aged eighty, of cachexia from an oesophageal pouch, at Hintlesham, near Ipswich, where his clergymen ancestors had lived for generations. His name will live in the history of civilisation as that of a man who wrote on the purity of sex and who rationalised the subject so that sane discussion of sex will always be perfectly respectable.

COLOUR TELEVISION

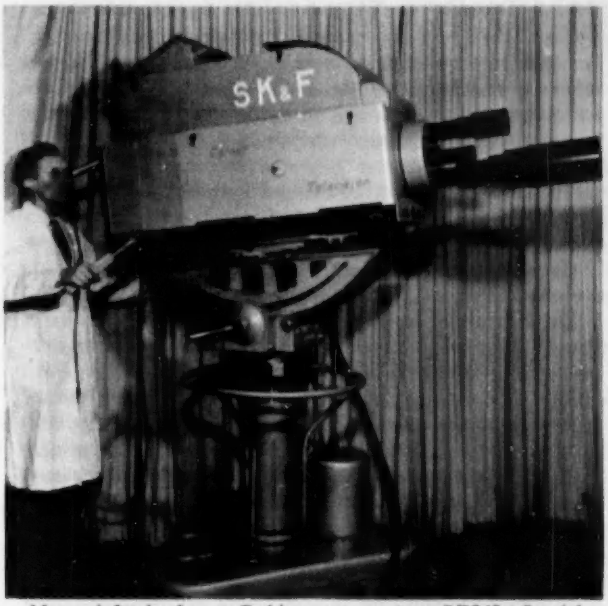
Since the demonstration by the British Broadcasting Corporation and Guy's Hospital Medical School in November 1957 (DISCOVERY, 1958, vol. 19, No. 2, p. 49), the medical faculty of the University of Marseilles have placed an order for a colour camera and projector with Philips of Eindhoven. In this country, the pharmaceutical manufacturers, Smith Kline and French Laboratories Limited, have extended their American service by purchasing a mobile colour television unit from the Marconi Wireless Telegraph Co. Ltd, the first to be designed and built in Great Britain.

The vehicle, which weighs 6 tons, carries 2 tons of television apparatus in three separate compartments. In the rear section a maintenance engineer services the apparatus, which combines the red, green, and blue signals for transmission by land-line or microwave link. The central compartment accommodates the technical director, the vision-mixer, the sound-mixer, and two camera-control operators under the overall control of the producer. The colour monitors, one for each camera, and the line monitor are attached to a monorail, so that they can be removed for maintenance to either one or the other of the two end compartments. The third section, normally reserved for the driver, can also be used for servicing.

The two Marconi 3-tube Image Orthicon cameras have been developed from those which were supplied to the British Broadcasting Corporation a number of years ago. The Marconi Colour Television Projection Unit can produce an image 8 ft. × 6 ft. for viewing by an audience of up to 300. A two-way radio link is available to facilitate direct discussion between the audience and the television demonstrator.

The equipment was formally handed over on June 4. Since then it has been used at King's College Hospital, London, and during the British Medical Association Annual Conference in Birmingham in July. Before the end of 1958 the unit was made available for the Visual Aids Seminar of the British Medical Students Association in September and for the November meeting of the Anatomical Society at Guy's Hospital Medical School. The owners intend to place this colour television unit at the disposal of congresses and conferences where it is desirable that large audiences should gain a close-up view of clinical demonstrations or of surgical operations. No charge will be made for this service.

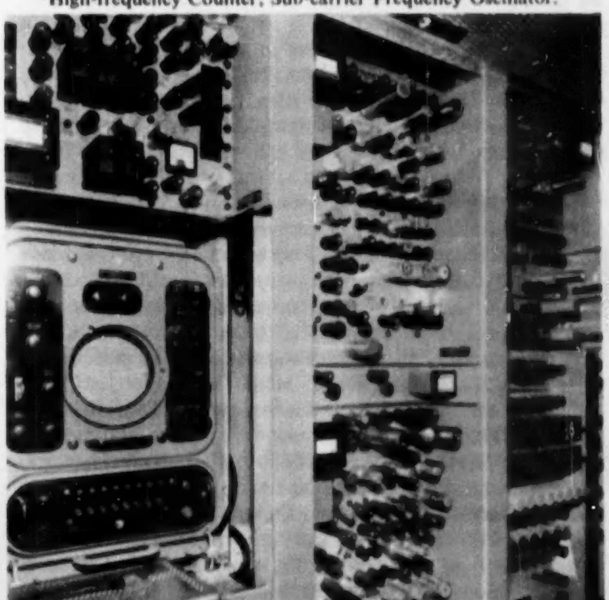
General view of the vehicle.



Marconi 3-tube Image Orthicon camera type BD848. Special features include finger-tip control of camera position, an independently inclined electronic view-finder (*top, left*) and an adjustable ventilator (*top, right*) for additional cooling when very hot.

(Photographs by courtesy of Marconi's Wireless Telegraph Co. Ltd)

Part of the Apparatus Room (rear compartment), including: *Left* (*top to bottom*), Colour Bar Generator; Vectorscope type BD881; Waveform Monitor. *Centre* (*top to bottom*), No. 1 Colourplexer and Phase Shifter; No. 2 Colourplexer and Phase Shifter; Vision Patching Panel. *Right* (*top to bottom*), Grating and Dot Generator; Synchronising Pulse and Burst Mixer; Burst Gating Pulse Generator; Synchronising Pulse Generator; High-frequency Counter; Sub-carrier Frequency Oscillator.



PALYNOLOGY—THE SCIENCE OF FOSSIL POLLEN

An invisible rain falls seasonally on the earth. This is a rain of pollen grains, incalculable numbers of which fill the atmosphere but which are so extremely minute that one is never aware of them, except that some cause seasonal hay fevers.

They are deposited in extremely thin layers over the earth's surface. From this pollen, preserved in sediments, geologists have been able to reconstruct vegetation, climates, and living conditions of millions of years ago in some localities.

The interpretation of fossil pollen and spores constitutes a very interesting science called palynology. It is summarised by Drs Estella B. Leopold and Richard A. Scott of the U.S. Geological Survey in the most recent annual report of the Smithsonian Institution. There is every indication, they say, that fossil pollen will be an increasingly valuable tool of geology as interpretation techniques are improved.

The pollen grains in the atmosphere are, for the most part, from plants which depend upon the wind, rather than insects, for pollination of their flowers. Wind pollination is an extremely wasteful process. Vast numbers of pollen grains may be produced—as many as 10 million per catkin for one forest species.

These grains are exceedingly resistant to destruction or change through the ages. This is due to the remarkable resistance of their walls to most disintegrating processes. The walls are composed of a wax-like compound, a chemically undefined polymer of stable, long-chain molecules which is one of the most enduring organic substances found in nature.

Many plant species produce distinctive pollen which can be distinguished by the expert. For palaeontological purposes, fossil pollen serves as a means of determining the botanical relationship of plants in a group. Having identified the pollen, the analyst, assuming that time has not significantly changed the plants' environmental tolerances, can deduce that an environment now required by these plants once existed in the vicinity of the fossil locality.

If a modern species is now limited in its distribution by some known factor such as temperature or rainfall, then from a Pleistocene (Ice Age) occurrence of the plant one can infer rather precisely the climate at the time the plant grew. The validity of such conclusions decreases with increasing age of the sample.

An outstanding example of the use of fossil pollen, also with fruits, seeds, and wood, in the reconstruction of an Oligocene environment is the investigation of the Brandon lignite. This unusual deposit of brown coal near Brandon, Vermont, U.S.A., was first discovered about 100 years ago and served as the fuel source for an iron industry, once the largest in the United States. Recent study of the lignite by E. S. Barghoorn and A. Traverse has resulted in identification of more than fifty-six genera of flowering plants. About 60% of these are represented by pollen alone.

The affinities of these plants reveal that they formed a subtropical group which probably grew under conditions much like those of the river swamps in the Atlantic-Gulf coastal plain. This is strong evidence for the existence in Vermont of climatic conditions similar to those now typical of coastal Florida or South Carolina.

From studies such as that of the Brandon lignite it is clear that palynology can contribute to a fuller understanding of the evolutionary and migrational history of past and present vegetation by adding another category to the list of detached fragments from which the geological record of plants must be deduced.

SCIENCE AND RESEARCH IN EAST GERMANY

One of the most interesting aspects of scientific education at the universities of Jena and Dresden in East Germany is the combination of academic with industrial training. At Jena a year's industrial experience is required before students can complete their courses. This experience need not be earned at one stretch, and students frequently work during vacations to fulfil the requirement.

Jena, with a total enrolment of 4830, is the leading research and teaching centre among the older universities. It has merged with such modern scientific industries as the Carl Zeiss Optical and Photographic Works, and Schott, the glass manufacturers. Many of the undergraduates work for Zeiss during vacations, and graduates are absorbed by this firm in large numbers. Zeiss provides the university with up-to-date equipment such as the electron microscopes for the Physics Department, and also sponsors a great deal of the research carried out in the laboratories.

This close connexion between education and industry is even more marked at Dresden, where there are 19,000 future technologists and scientists. Not all of these are full-time undergraduates in the British sense. Peculiar to the East German social organisation is the existence of a Faculty entirely devoted to providing pre-university courses for children of workers and peasants who have missed secondary schooling. Sixty-one members of the academic staff are full members of the teaching faculty, and subjects are taught, in effect, on the level of the secondary school. In this Faculty students can take three-year courses which will prepare them for university entrance.

There are only a few hundred such students at Jena, whereas there are 1100 of them at Dresden; 90% of them are fully grant-aided, particularly the many students from Korea, China, and the Balkan countries. Although officially students are selected for this Faculty on the basis of academic attainment alone, it has been implied that membership in the Free Germany Youth and outstanding "leadership" qualities are also advantageous. There is a very modern medical centre where treatment for tuberculosis and rest are provided free. The General Practitioners in the university town also provide free medical care for the students.

Adult continuation courses are offered at the Industry Institute, where there is a two-year refresher course in technology for a specially selected group of men in top industrial posts. Economics and aspects of management occupy a large part of the syllabus. The staff is drawn from the large engineering and science schools and from the Faculty of Economics, which also provides tutors for the required courses in Marxist theory.

The Correspondence School assists 4000 others, mostly younger people, who wish to improve their standing or are seeking promotion in their jobs by qualifying at Dresden or at any of its outlying correspondence centres. The greatest demand appears to be for courses in machine and electro-engineering, management, chemistry, physics, and teacher training. On closer scrutiny this last proved to be advanced tutorial courses in education for teachers already in the profession and seeking promotion.

Dresden is staffed and equipped on a scale greater than even the largest Technische Hochschulen in the West. State expenditure for Dresden rose between 1951 and 1956 from 28·3 million to 93·7 million DM (Western), and a vast building programme for student hostels has been under way since 1949. Student enrolment has risen accordingly so that the total is now 19,000. With such vast numbers, it is difficult to see how the recently introduced compulsory "Consultations" can be successful. These are personal or small group tutorials devised to establish a modicum of contact with the professor. In fact, it is already the case that these tutorials rely on assistants and lecturers, and are hardly ever taken by the professor.

LADDER OF LIFE

There is new information that suggests that the ladder of life on earth, from the non-living to the highest types of plants and animals, can now be followed rung by rung.

It now seems possible, after recent revolutionary chemical developments, to find the actual laboratory synthesis of a structure having most of the properties of a living agent.

The remarkable recent progress in breaking down the barriers between molecules and organisms is described by Dr Wendell M. Stanley, Director of the Virus Laboratory of the University of California, in the Annual Report of the Smithsonian Institution.

Dr Stanley is the chemist who, more than twenty years ago, demonstrated the true nature of filterable viruses, the still somewhat mysterious particles, among which are the agents of some of the most devastating diseases.

The remaining essential step, he says, seems to be to synthesise one of the chemically highly complicated nucleic acids which forms an essential component of viruses and of genes, the units of heredity. This may be close at hand.

The ladder of life, as pictured in the report, is essentially as follows:

Nucleic acids, major constituents of genes, the units of heredity.

Viruses, which incorporate nucleic acids and which under appropriate conditions not only can multiply but which can mutate into new forms.

Single-celled living things, such as bacteria and protozoa.

Multi-celled organisms comprising all higher forms of life.

The barriers between these have broken down one after another in the last few years. This progress seems to have culminated very recently in a demonstration by Dr H. Fraenkel-Conrat at the University of California; it was found that one of the nucleic acids may have all the essential properties of a gene or of a group of genes. Already proteins, the real building stones of life, have been produced from amino acids.

This possible road to life synthesis may be considered to have started with the discovery of viruses as the agents of certain plant diseases about fifty years ago.

They were sub-microscopic particles which, it was demonstrated, possessed two of the distinctive properties of living organisms. They could multiply. They could undergo hereditary changes. They could multiply, however, only in one environment—a living cell. Moreover, it appeared that a specific virus could multiply many times only in a specific kind of cell.

It soon became apparent that quite similar particles were responsible for many animal diseases.

There was, however, an enormous gap between a virus and any known living thing. The smallest bacterium, for example, was ten times the size of any of the first-known viruses, which were comparable in dimensions to large molecules. Any actual cell contained many molecules. Dr Stanley demonstrated that viruses could be crystallised like various inorganic chemical preparations.

Within the last few years the size barrier has completely broken down with the finding of larger and larger viruses. Now the gap between virus and single-cell organism is completely filled. There is even some overlapping. With present techniques an enormous number of new viruses have been discovered. Relatively few are agents of any demonstrable disease. Human beings may contain many viruses which continue to multiply generation after generation without seeming to do any harm.

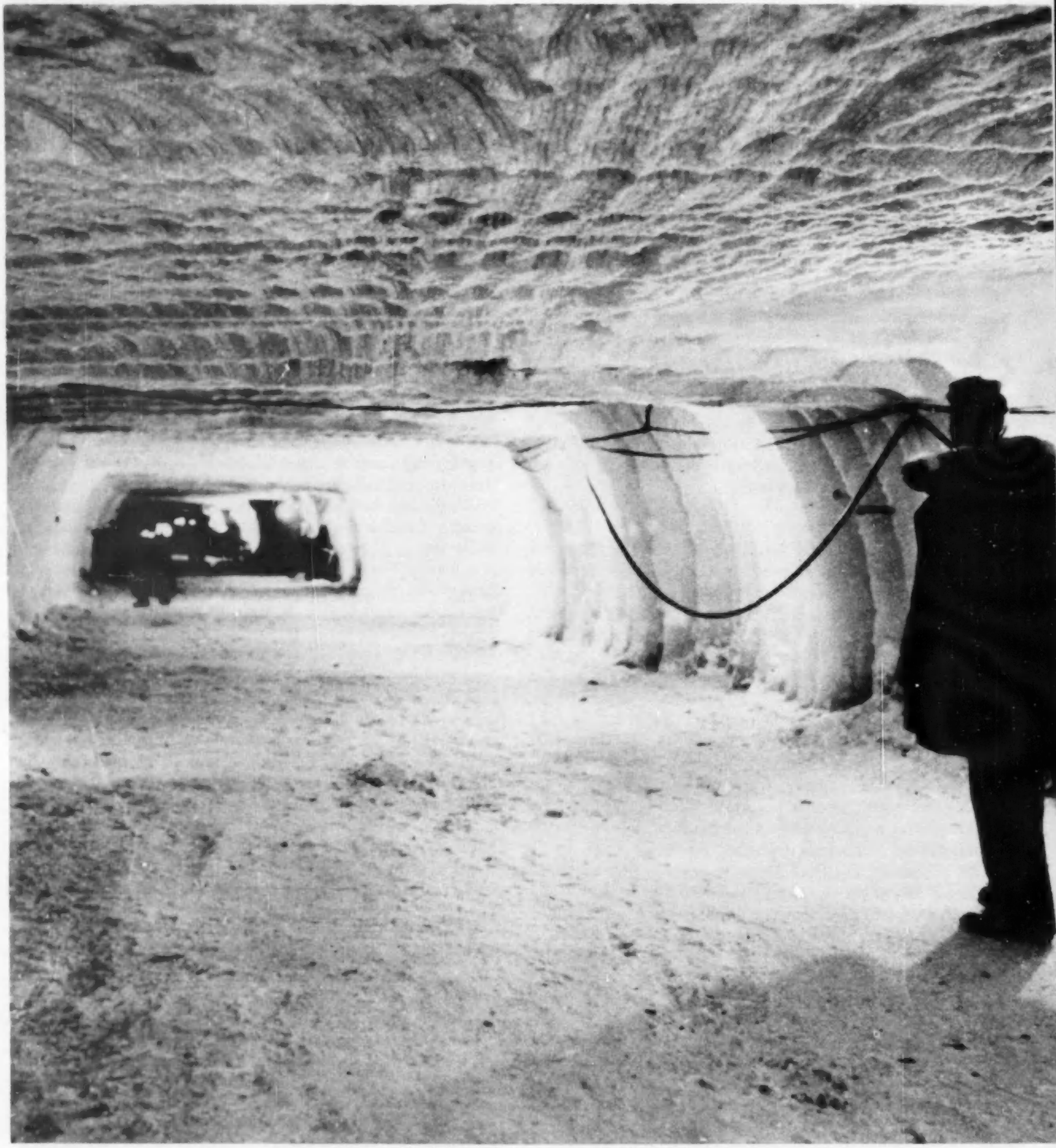
Perhaps of even more significance than filling the size gap have been demonstrations of the extreme mutability of the particles. New forms are likely to be produced at any time and continue in hereditary lines. This possibility for change, responsible for all evolution, is considered a unique character of life.

Thus an almost unbroken series of bonds now exist between the undoubtedly living and the crystallisable "non-living". The recent finding that one of the nucleic acids itself has the capacity for both heredity transmission and change nearly completes the connexion.

The remaining step seems to be the synthesis of this nucleic acid out of its constituent parts, the purines, pyrimidines, and sugar molecules, just as proteins have been synthesised from amino acids. It would be one of the outstanding events in the history of science.

An extremely fruitful field now opening is that of the possible relation between viruses and human cancer. The fact that certain of these "half-alive" particles are the agents of various animal cancers is now recognised. By preparations of the virus these can be transferred from one individual to another. But malignant neoplasms of man have generally been assumed to be non-transmissible.

But here, the report points out, the increasing host of "silent viruses" found in man, with their extreme capacity for mutations into virulent forms, offer a great area of research.

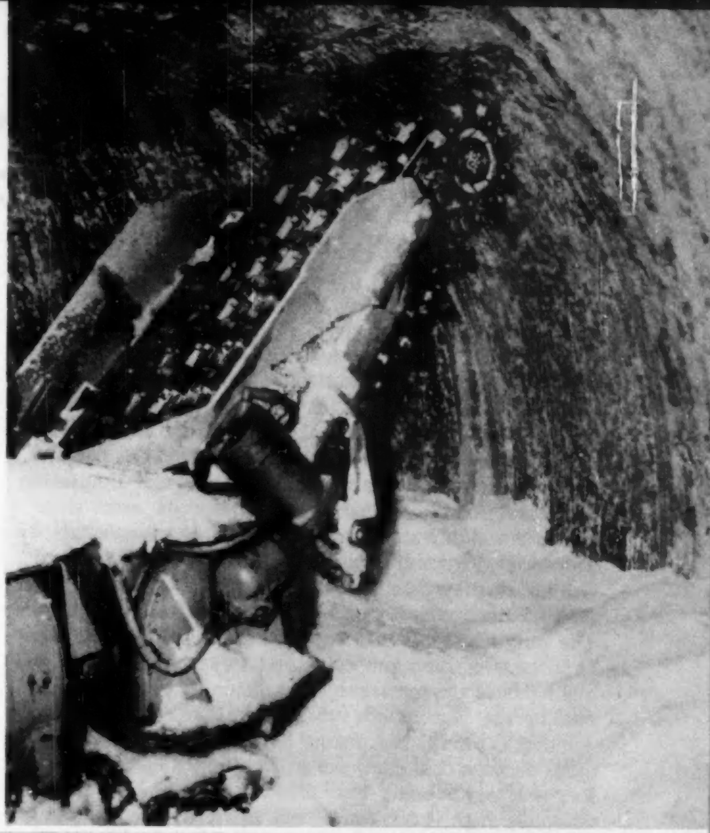


A single section of the ice tunnel. There are 1547½ ft. in this section.

ARCTIC ICE TUNNEL

At the edge of the ice-cap glacial ice is exposed. United States Army Engineers' soldiers and scientists have carved a tunnel 1150 ft. long into the ice-cap. This was a research project of the Snow, Içe, and Permafrost Research Establishment (SIPRE), Wilmetts III—the Corps of Engineers' laboratory. Tunnels in this ice could provide means of storage, transportation, quarters, shops, and other facilities with a high degree of protection. Hence the engineers have developed the special technique of tunnelling in the ice.

(Right) The cutter head, a piece of equipment known as the Joy Continuous Miner. It has a head consisting of chain saws (like teeth) which shave the ice face.



(Below) The tunnel portal. Long view of the conveyor-belt carrying ice from the mining machine out of the tunnel. Ice cuttings are moved on the conveyor. The boards erected above the entrance protect the workers from stones rolling down the slopes.

THE UNITED NATIONS DEBATE ON SPACE

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Discovery's Special Correspondent to the United Nations, New York and Geneva

When the new Soviet planet passed the Moon, it also by-passed the momentous debate which concluded the UN's Annual Assembly in New York a few days before Christmas, but which has received all too little publicity in the general Press. In fact, an hour or so before the end of this final meeting a vote was taken among the eighty-two member States present which will, unfortunately, tend to tie the hands of the national governments until the item "International Co-operation in the Field of Outer Space" again appears on the UN agenda at the Fourteenth General Assembly next autumn.

The seven-day debate, which began so promisingly by wide agreement on the general principles of space "control", was initiated by rival proposals submitted earlier last year, first, by the Soviet Union and, later, by the United States. The purpose of this article is, therefore, to examine what happened to those proposals and to record a few of the highlights of the remarkable discussion to which they gave rise in the Assembly's vociferous Political Committee. Though the many discussions did not result in the unanimous decision that many delegations hoped for and pressed for, it is nevertheless true that the speeches were of an unusually high order and served to clarify the attitude of the world's governments towards the novel and exciting problems of the Space Age.

JAPAN'S OPENING PLEA

As Ambassador Matsudaira of Japan pointed out early in the discussion, in pleading for "a new dimension" in world political and legal concepts: "This age seems to be full of hope, and yet, at the same time, it is fraught with immense danger. To eliminate this danger, we must affirm unequivocably and now our common aim, which is that outer space should be used for peaceful purposes only." And he went on to lay down a basic proposition which was not contested by any other participants in the debate:

> "International scientific co-operation in the field of space research has thus far been undertaken by the International Council of Scientific Unions, and under its aegis the programme of the Internationl Geophysical Year has been conducted and a Committee on Space Research has been established (COSPAR). To put, however, such co-operation on a permanent and more solid basis, the United Nations is, in the view of my delegation, the most appropriate organisation, inasmuch as the United Nations can command a wider latitude in approaching the problems of international co-operation in the peaceful uses of outer space than any other international organisation."

RUSSIA'S CONSTRUCTIVE APPROACH

Not unnaturally, the Soviet Deputy Foreign Minister, Valerian A. Zorin, opened his case by stressing that "the launching by the Soviet Union in October 1957 of the first artificial earth satellite has inaugurated a new era in the history of mankind. The scientific and technical task of overcoming gravitation may be regarded as solved. The road to outer space has been opened for mankind." But he introduced an "omnibus" resolution (summarised below) which left no doubt that the policy of the Soviet Union is to encourage the future planning and development of space exploration jointly with other nations under the auspices, directly or indirectly, of the United Nations. This is how he put it:

> "Unfortunately, we have witnessed how progress in the decisive fields of science and technology, including the field of control of the cosmos, is being shifted into military channels. The unbridled armaments race which has spread the weapons of mass destruction, such as atomic and hydrogen bombs, has already been shifted to the creation and perfecting of rockets and missiles that are using the cosmos space in their trajectories. . . . That being so, the Soviet Union is prepared immediately to conclude an agreement calling for the prohibition of the military utilisation of cosmic space and the launching of rockets into outer space only in accordance with a co-ordinated and agreed international programme of scientific research. . . . Such an agreement would open the door wide to large-scale international co-operation in the peaceful uses of cosmic space. It would lay the foundation for a joint study by scientists from all countries of the various problems related to the cosmos and interstellar space."

There could be little doubt that this pragmatic and constructive approach won favour with most delegations. The fact that the Soviet Union could quite overtly come to the Assembly, and, in spite of its own outstanding technical lead in space exploration, offer to place its unique experience and equipment at the disposal of the world community, through the creation of a permanent agency of the United Nations which would possess the administrative and scientific machinery to plan and control future space development, represented both a psychological and diplomatic success for the Russians which has not, unfortunately, received its due emphasis in the general Press.

BRITISH NEUTRALITY

It was even more unfortunate when, later in the debate, the United States delegate referred to these revolutionary proposals for specific UN supervision as "paper promises", for everybody knew that it was the other way round. In fact, the United Kingdom delegate, whose general attitude was charmingly noncommittal, was evidently caught on the horns of the same dilemma. "The machinery envisaged in the Soviet draft," said Sir Pierson Dixon, "is too ambitious in the present initial stages of the problem. To set up an Agency would, in fact, be asking the international community to run before it can walk along these uncharted shores. . . . To set up a fresh Agency to deal with outer space, before we have at least some idea of what is involved,

would, I am sure, complicate rather than advance matters." Yet, a few moments later, Sir Pierson was warning his hearers against this very lethargy. He said:

"The breakdown of the barriers between mankind and outer space is a capital event in the age-long history of this planet. Let us not make the mistake which mankind has made so often when confronted with a new element or a new field for conquest by human endeavour. There are so many examples that there is no need to quote more than one, the most recent and perhaps the most lamentable example of a great opportunity missed—the failure at the end of the war to adopt the principles in regard to the use of atomic energy advocated on behalf of the United States by Mr Bernard Baruch. Let us, therefore, try to make progress in this new field, which has such an inspiring future and, so far as mankind is concerned, no past to bedevil it."

None the less, it was significant of the refreshing catholicity of the debate as it developed, that Dr Pinochet of Chile brought together, almost in the same breath, the initiative of the Russians with the admonition of the Holy Pontiff, when he quoted the July 1958 issue of the Soviet magazine, *USSR*, as asserting that "the joint exploration of space on the part of Soviets and North Americans has in the future great possibilities of combining human knowledge and ability in one great united effort; it is the fervent hope of the Soviet scientists that these possibilities will become a reality". And he then cited the late Pope Pius XII, at the Seventh International Astronautical Congress, held in Rome in September 1956, as saying: "The most audacious explorations of space can only serve to introduce a new cause of division between men unless concurrently there is a moral and more profound reflection, and a more conscious attitude regarding the higher interests of humanity."

ITALIAN VIEWS ON SPACE LAW

The Italian delegate, Prof. Antonio Ambrosini of the University of Rome, underlined that the first attempt to reach and explore space had enlisted the consent of all States. "In fact," he said, "tacit and unanimous agreement obtained between these States in the sense of allowing, during the geophysical year, the launching and circulation of rockets and artificial satellites which practically overflew all the territories of various States without any protest being made on the grounds of violation of sovereignty." Both the U.S.S.R. and, immediately after, the United States had obtained valuable results in this field, and they succeeded in orbiting *Sputniks* and *Explorers* whose radioelectric signals had already supplied fundamental information for the subsequent exploration of cosmic space; especially as regards the thickness of the ionised layer whose radiations could be fatal for human beings who in the near future might fly through it.

In turning to "the need to determine the juridical nature of cosmic space and, consequently, the ways, the means, and the possible limits of its utilisation," Prof. Ambrosini stated that "the closest example at hand with which this topic would seem to a certain degree to converge is aviation, which also is the science and practice of human flight". Nevertheless, he insisted, "the basic problem in this matter, the question of the *sovereignty* of States, may arise in a profoundly different way for conventional aviation, which uses machines that fly only through the air space, than for astronautics, which uses other kinds of machines which do not need air to travel through space." And, having noted that "at the present stage no norms of international law define the *legal* nature of extra-atmospheric space," he asked the question: "What is or can be the juridical status of these lofty spaces? Can States pretend that their sovereignty projects beyond the air space and consider any part of these cosmic spaces to be part of their territories?"

"These theories" [continued the speaker] "had the grave shortcomings of including within the sovereignty of a State a space which is never fixed or determined, and which changes incessantly through the effect of the rotation of the Earth. This space would, in fact, have a conic form. Its point would be at the centre of the Earth, and it would rise through the frontiers of a State towards the sky. If we look at the Earth in this light, the result will be a series of cones corresponding to various States, but these cones will be constantly changing their position in space following the movement of the Earth."

And so Prof. Ambrosini concluded:

"Is it physically or juridically possible to conceive of sovereignty over air space which is never the same and which varies swiftly with the velocity of the Earth's rotation? Certainly not, because this would lead to a conclusion which cosmographically and juridically would be absurd. It is for this reason, perhaps, that Prof. John Cobb Cooper abandoned his original theory and that he states today that the sovereignty of States extends only to the point where conventional air vehicles now in use can support themselves and fly about in air space, adding to this zone of full sovereignty a subsequent space which, following the example of the sea, he calls the 'contiguous zone' where limited rights are to be exercised by States."

The Italian delegation therefore urged the UN Assembly:

(1) To request all States to postpone the termination of the Geophysical Year, until the Committee mentioned below should have submitted its recommendations to the Assembly.
(2) To set up, as the delegation of the United States had proposed, an *ad hoc* committee to undertake the necessary study and recommend special measures that the Assembly might adopt to guarantee that outer space shall be used only for the benefit of all humanity.
(3) To charge this committee with the study of the juridical problems that arise regarding the exploration of outer space.
(4) To recommend that this committee work in close co-operation with other organs directly concerned with the problem such as the International Civil Aviation Organisation and the International Telecommunications Union.

The Italian view has been stated *in extenso* because it was generally representative of that of the smaller nations, who frankly admitted their inability, on economic and financial grounds, actually to produce and launch (at least, at this stage) Earth satellites; but who, nevertheless, were directly and vitally concerned that the two Space Powers

should not engage in a suicidal "race for space" between them for overtly or thinly disguised military ends, but should pool their programmes and scientific resources through the United Nations for the common good and the common peace.

U.S. PRECEPTS AND PRACTICE

In accepting this prevailing attitude, the United States delegate (Mr Cabot Lodge) stressed that

"each of us has been struck by the sudden realisation that despite all the things that divide us, we are all men living together on the same planet and are all affected by these newest triumphs of human ingenuity and labour. The challenge is great and the stakes are certainly high. We can use this new dimension to destroy ourselves through the extension of national rivalries into outer space or we can use this new development as a vehicle for international collaboration and harmony."

And Mr Lodge summed up the aims of such an approach as follows:

"First, it could provide a new vantage point from which we could study the nature of the universe, the nature of matter, the nature of man, the nature of the Sun and the Moon, and the nature of the Earth. Secondly, it could provide greatly increased knowledge of meteorological phenomena, cosmic rays, medicine and biology, geophysics and magnetic phenomena. Thirdly, the opportunity to improve understanding of the weather and to improve weather forecasting. Fourthly, the improvement of radio, television, and telephonic communication. In fact, it will be possible in the future to establish a world-wide communication and television network which can increase our knowledge and understanding of each other and which can lead to an open world of open societies based upon mutual trust and respect."

So much for the precepts. The practice was quite another thing. An attempt must now be made to explain what happened when the two Space Powers were brought face to face with the need to agree on a common formula of co-operation in space.

As stated above, there were originally two draft resolutions presented to the Assembly. The first was submitted by the Soviet Union on November 7, 1958, calling on all UN members to conclude an agreement based on the following principles:

(1) A ban on the use of cosmic space for military purposes and an undertaking by States to launch rockets into space only under an agreed international programme.
(2) The elimination of foreign military bases, primarily in Europe, the Near and Middle East, and North Africa.
(3) The establishment of international controls within the United Nations framework based on the obligations above.
(4) The establishment of a United Nations Agency to work out an agreed international programme for launching intercontinental and space rockets with the aim of studying cosmic space and supervising the implementation of this programme, and which could continue on a permanent basis the cosmic-space research now being carried on within the framework of the International Geophysical Year and especially co-ordinate national research programmes and render them all possible assistance.

Not unnaturally, the reference to "foreign military bases" immediately put the fat in the fire. Thereupon, on November 13, the United States submitted its own draft resolution, supported by nineteen other delegations, whereby the Assembly would:

(1) Establish an *ad hoc* committee on the peaceful uses of outer space, consisting of the representatives of . . . and request it to report to the Fourteenth Session on the following:
   (*a*) The activities of the UN and of other international bodies relating to the peaceful uses of outer space;
   (*b*) The programmes of international co-operation which could be undertaken under UN auspices;
   (*c*) The nature of the organisational and legal problems which might arise under these programmes.
(2) Request the Secretary-General to assist and to recommend other steps within the framework for the useful uses of outer space.*

It will be observed that all parties agreed, in principle, to the UN becoming the common instrument for future space research, exploration, control, and development—a remarkable coalescence of human thought. But, whereas the American "side" called for, virtually, a year's "study" of the question, the Communist "side" had teleported the controversial military bases issues into "space" and called specifically, here and now, for the establishment of a UN Space Agency.

POLITICAL SQUABBLES

When it became clear, from objections all round the Assembly Hall, that any resolution linking terrestrial bases with space-travel would stand no chance whatsoever of getting anywhere, the Soviet delegation on November 18 astutely submitted a revised version. The new resolution dropped the bases completely, and asked the General Assembly to:

(1) Recommend the establishment within the UN framework of an International Committee for co-operation in the *study* of cosmic space for peaceful purposes.
(2) Set up a preparatory group of eleven countries, consisting of the Soviet Union, the United States, and nine others, to report to the Fourteenth Session on all other aspects of its work as outlined in the original resolution.

This was a clever move, for nobody could really reject on political grounds so altruistic a resolution. In fact many "neutral" and Latin American delegates went to the tribune and urged that the U.S. and the U.S.S.R. should get together and produce jointly a form of words which could be passed unanimously. Whereupon, on November 21, the U.S. group revised their original 20-Power resolution and incorporated most of the Russian points in it, but substituted an 18-Power Committee (with only three Communist countries

* This became the main resolution, passed 54 to 9 and 18 abstentions.

on it) for the Russians' original 11-Power Committee (with four of them Communist).

This was where the split ran down to the roots of the world political struggle. In spite of some remarkable concessions by the Russians, which pushed up the total of their proposed committee by stages from eleven to fifteen members, the Americans would not budge from their 18 Powers and the Russians would not give up their fourth seat. So, in spite of efforts behind the scenes by the "neutrals"—a sad story too complicated to be told here—a final vote resulted in the Assembly "dividing" outer space on the all too familiar "cold war" lines and left most of the delegates, who had striven so hard for unanimity, bitterly disappointed.

Only the American Press appeared pleased with the result (which gave the missile-men another clear year to develop their programmes without any interference from the UN) and put all the blame on the Russians for their expected veto. Undoubtedly the Russian Press, in turn, has echoed their own spokesman's jibe from the Assembly tribune: "We *told* you so!"

The final vote in the Assembly was 54 to the 9 Communist countries, with *18 abstentions.* Thus an *ad hoc* committee is to be set up to "study" the space question in terms of the general principles outlined above, consisting of Argentina, Australia, Belgium, Brazil, Canada, Czechoslovakia, France, India, Iran, Italy, Japan, Mexico, Poland, the Soviet Union, Sweden, the United Arab Republic, the United Kingdom, and the United States, which committee of eighteen members is to report to the 1959 Session. But both before and after the vote was taken, the Russians announced that they would not participate in the work of the Committee and, presumably, this applies equally to the other two Communist countries named and, possibly, also to the three countries on the foregoing list which abstained in the voting. The Americans, therefore, are left with an unrepresentative committee of doubtful value.

Whether, in fact, the Soviet Union will change its mind and actually participate, is not yet known, though several delegates earnestly begged the Russians to climb down and do so. Such national magnanimity in the cause of world peace is unfortunately rare. "Go ahead and vote your majority," declared the Soviet Deputy Foreign Minister. "Nothing will come out of it. There will be no progress. No headway will be made on this question."

Happily for the human race, outside the United Nations, Russians and Americans are apparently co-operating more closely than before on the continuation of the space aspects of the IGY carried into 1959. "Not by Eastern windows only, when daylight comes, comes in the light!" The new Committee on Space Research of the Council of Scientific Unions, COSPAR, was holding its first meeting in London at the very moment when cosmic space was being carved up so vacuously by the political "cold warriors" in New York.

First Committee Debates Peaceful Uses of Outer Space. The First (Political and Security) Committee of the UN General Assembly began the general debate on the question of the peaceful uses of outer space in New York on November 12, 1958. Among the delegates seen in this photograph are Mr V. A. Zorin, U.S.S.R. Deputy Minister of Foreign Affairs, addressing the Committee, and (*front row, left to right*): Mr Henry Cabot Lodge (U.S.A.), Sir Pierson Dixon (United Kingdom), Mr Omar Loutfi (United Arab Republic), and Mr Zorin.

(United Nations photograph)

THE SCIENCE OF SCIENCE

What Scientists Read and Why

CHRISTOPHER SCOTT, M.A., F.R.S.S.

There are few things on earth that are not studied by some kind of scientist, yet up to ten years ago one subject seems to have entirely escaped scientific investigation, and that was science itself. Of course philosophers have been telling us for many years what they believe science is and how they think scientists operate. Most of us learned at school some such story as this: (1) The scientist collects some observations; (2) he examines them and formulates a hypothesis; (3) from this hypothesis he draws a deduction; (4) he tests this deduction by an experiment. Modern philosophers are more sophisticated than this and give a more complex account of scientific behaviour, but they are still philosophers and not scientists, which means that they base their opinions on thinking and not on systematic observation. None of them has ever sent a team of investigators into a sample of laboratories to find out what scientists actually do.

One reason why there is no science of science may be that science is so successful (see DISCOVERY, 1958, vol. 19, No. 1, p. 1). Because its progress is so rapid and so obvious, it may seem unnecessary to ask how this success is achieved, and until science begins to bog down there is no incentive to examine the causes of scientific advance. But there is, even today, one problem which seems already to be threatening the progress of science and it is here that the beginnings of a science of science can be seen. The problem is that of scientific communication. It is now well known (see DISCOVERY, 1956, vol. 17, No. 6, p. 240) that the world output of scientific information is increasing roughly exponentially, but the time available to any given scientist for reading or listening cannot be appreciably increased. Therefore the *proportion* of the current output of information that can be communicated to any given scientist must inevitably decrease. Does this form a natural barrier to the speed of scientific advance? This question has been asked many times in recent years, and there are by now quite a number of groups in different countries trying to answer it. In November 1958 the International Conference on Scientific Information was held in Washington (see DISCOVERY, 1959, vol. 20, No. 2, p. 60) with the aim of examining progress made so far. Nine hundred experts attended from all over the world, and seventy-five papers were presented.

There seem to be two obvious lines of approach to a solution. Either we can reorganise the scientists (increase specialisation yet further, increase team research, with each member of the team bearing responsibility for slightly different areas of knowledge), or we can reorganise the scientific information services (improve abstracting, improve libraries and their cataloguing, and plan, more purposefully than at present, what information is to go to which scientist). Reorganisation of scientists is a process taking place throughout the world. No central body is planning it, almost no one is doing research to examine its effects,* it is simply being forced upon research directors because they are offered no other choice. Reorganisation of the information services, on the other hand, has been the subject of a great deal of talk and writing and a fair amount of research, and it monopolised the Washington conference. Here, in a small way and in a crude form, are beginning to emerge the foundations of a science of science.

* For an exception, see reference.[1]

WHAT SCIENTISTS DO

One can find out what scientists actually do either by watching them or by asking them. The method of observation is cumbersome, difficult to administer, and inefficient (in the sense that one gets relatively little information per unit cost of the inquiry), but within its limitations it is more reliable than the method of questioning, and there are some very fundamental questions which cannot be investigated in any other way. The only thorough observational study yet carried out was reported, in preliminary form, to the Washington conference by Halbert and Ackoff.[2] About 18,000 observations were made, at random moments during the working day, of approximately one thousand industrial chemists in the United States. Mean times spent by chemists in different types of activity are shown in Table I. Different groups of chemists spent widely varying times on the different classes of activity. One hundred groups of chemists were studied, and the table shows, besides the mean, the minimum and maximum times spent by any group.

TABLE I

Breakdown of Working Time of Industrial Chemists (U.S.A.)

Activity	*Minimum %*	*Mean %*	*Maximum %*
Scientific communication	15·7	33·4	61·4
Business communication	0·8	10·4	40·0
Thinking and planning alone	0·0	6·0	25·6
Setting up equipment	0·0	6·2	25·9
Using equipment	0·0	23·4	70·1
Treating data	0·0	6·4	31·6
Personal and social	0·0	9·8	33·6
Miscellaneous	0·0	4·4	13·6

Based on Halbert and Ackoff.[2]

We are apt to think of the scientist as spending most of his time doing experiments or making observations (setting up or using equipment). It seems a plausible guess that the chemist does more of this than most scientists, yet the table shows that even the chemist spends less than 30% of his time in this way. This is a useful reminder of how distorted our views can be of what scientists do.

Almost all other systematic inquiries into scientific activity have relied on the scientist's ability to observe himself. The dangers of this approach are known to every

psychologist, but the advantages are obvious. Three methods of inquiry have been used: the interview, the diary, and the mailed questionnaire. Again each has its advantages. Interviews can collect more, and more varied, information. Diaries are more reliable, *provided* they are complete and are filled in at the time and not just before they are due for collection (and this means provided they are very simple). Mail questionnaires are much cheaper. The rest of this article will describe some results of an interview inquiry into the use of technical information by industrial technologists which was carried out in this country and reported to the Washington conference.

A GOVERNMENT SURVEY

The Department of Scientific and Industrial Research commissioned the Government Social Survey in 1956 to carry out an inquiry into the use of technical and scientific literature by industrial scientists and technologists.* Earlier surveys have shown (what seems obvious anyway) that scientists working in different fields have different habits in their use of scientific information, and again that pure scientists differ from applied. It follows that, for useful results, one must either strictly limit the types of scientists to be investigated or draw a sample large enough to ensure that the sub-samples of particular types of scientist within the main sample are large enough to give reliable results. The present sample was confined to people working in medium-sized firms (200–1000 employees) in the British electrical and electronics industry, and covered:

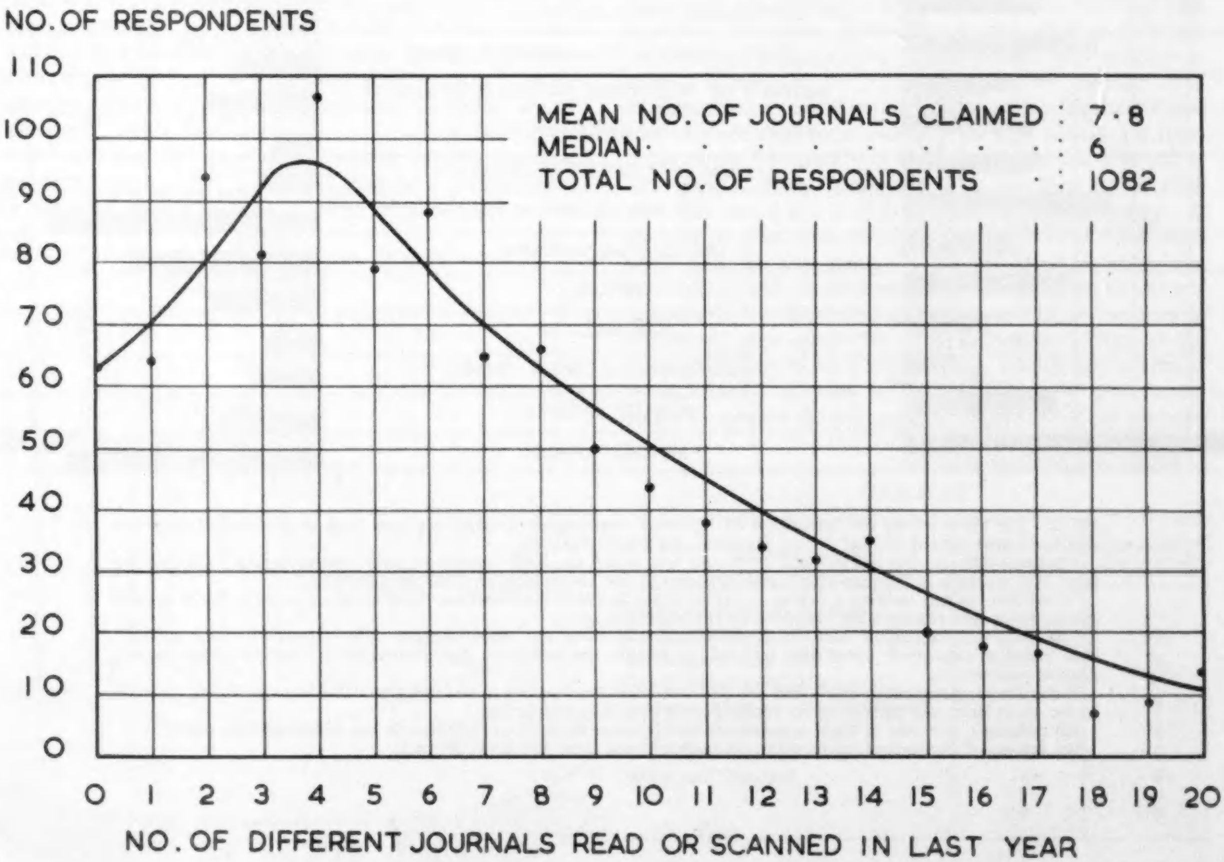
1. All those engaged in research, whether qualified or not.
2. All those with technical degrees or professional technical qualifications.
3. All those responsible for planning and development work.

From these groups a random sample of 1082 people was interviewed, made up as shown in Table II. It is obvious from the table that most of those interviewed were technologists rather than scientists, and for brevity we shall in future refer to them all as technologists.

The first object of the survey was to find the number and

* Fieldwork took place from February to April 1956. For full report of the survey, see reference.[3]

FIG. 1. Number of respondents plotted against number of different journals read or scanned in last year.



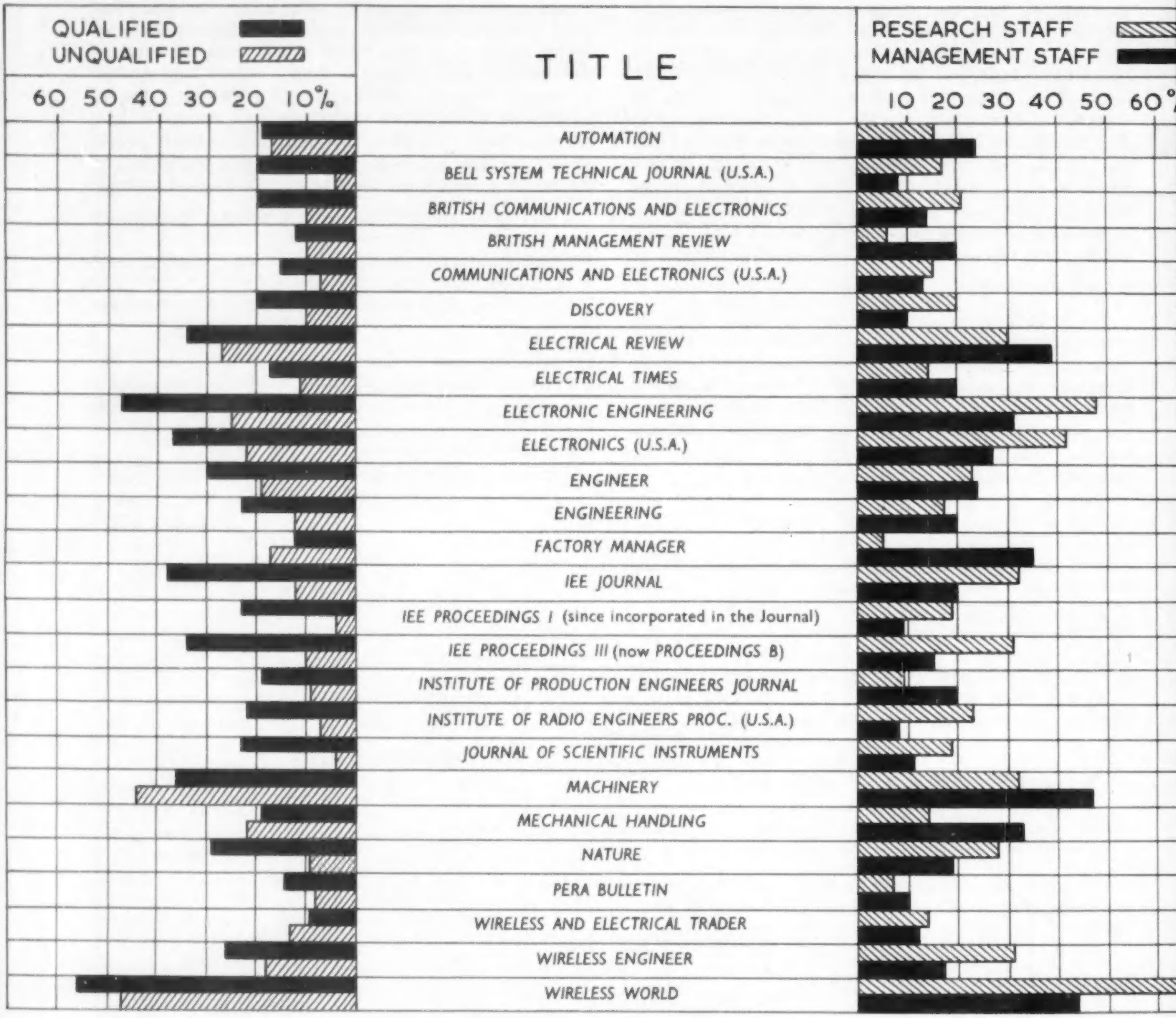


FIG. 2. The chart shows the percentage of interview respondents claiming to have read or scanned at least one article in each named journal during the preceding twelve months.

Figures relate to February–April 1956 and are based on 1082 interviews with "technologists" (defined on page 111) working in medium-sized establishments in the electrical and electronics industry.

"Qualified" means holding a degree or professional technical qualification. Staff claiming to be engaged in both management and research are classified as "management".

The categories "qualified" and "unqualified" together cover the whole sample. The categories "management" and "research", however, cover only 60% of the sample, the remainder (not shown) being mainly engaged in production supervision.

It should be particularly noted that the data are limited to readers in one industry. The less specialised journals in the chart have a relatively larger readership outside this population.

All technical, scientific or trade journals claimed by more than 10% of the sample are included in the chart.

See reference[3] for further information on readership of these and other journals.

TABLE II

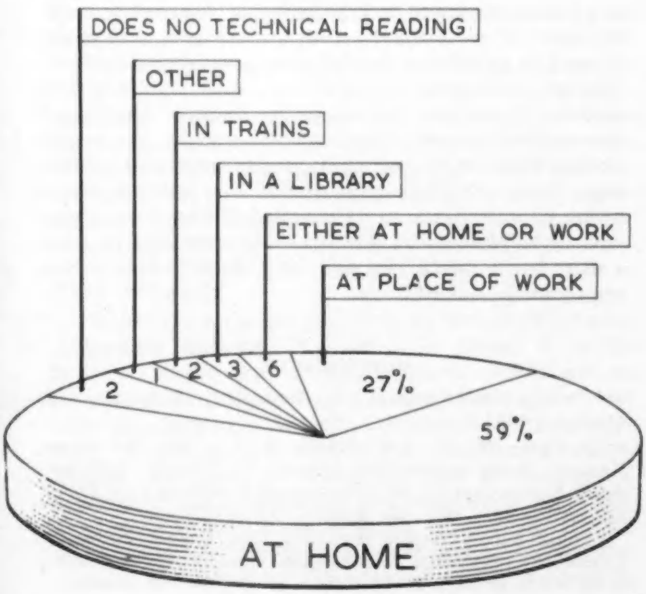
Duties	Qualifications			
	Degree	*Technical qualification only*	*No qualification*	*All*
Management	26	35	82	143
Research	131	118	213	462
Production supervision	26	72	333	431
Other	2	13	31	46
All	185	238	659	1082

type of readers of different technical journals. This was done in several different ways, one of which involved the use of a prompt-list of ninety-eight selected journals, including all journals having an appreciable readership among the sample. Respondents were asked to mark on the list the journals which they had read or scanned in the last year. This type of question is believed to lead to an exaggeration of the true readership figures, but the *relative* positions of different journals, particularly the well-known ones, is probably represented fairly accurately. Results for the most widely read journals are shown in Fig. 2.

Different people claimed to have read widely different numbers of journals. Fig. 1 shows the distribution. It was found that the person who saw more journals tended to be more active in all ways. On the average he attended more meetings and conferences, he was better qualified, he used abstracts more often, he was more likely to say yes to the question, "Are you working on any problem at the moment?", and so on.

The number of journals *seen regularly* (open question, no prompt-list) averaged 4·7 and showed a similar trend. In addition, respondents were asked whether they read or merely scanned each journal, and very little tendency was found for the proportion of journals scanned to increase as more journals were seen. This suggests that the technologist's reading is not seriously limited by shortage of time; he does not say to himself, "I want to see ten journals, but I have so little time that I will have to scan nine of them and read only one in detail." How, then, does he find the time? Fig. 3 may give part of the answer.

FIG. 3. "Where do you do most of your technical reading?"



Well over half the sample claimed to do most of their technical reading at home. It may be that some respondents thought that this answer gave a better impression to an inquirer, but we shall see later that the picture of a large amount of technical reading taking place in leisure hours fits well with other evidence about the role of reading in the work of a technologist.

WHY DO TECHNOLOGISTS READ?

The problem of distributing new scientific knowledge to the scientists who need it has roused the interest of many people concerned with science, but nearly all the systematic work devoted to it has been sponsored by a particular professional group who call themselves documentalists and most of whom are librarians by training. Other interested parties have done almost nothing. This, as we shall see, is a pity. The documentalists are an articulate and well-organised group who are very conscious of their position as providers of a service to other professions. Perhaps as a result they are inclined to excessive modesty, and they tend to believe that their service is not good enough, although the evidence suggests that, if not perfect, it is at least as good as it needs to be. In the Social Survey inquiry, 18% of respondents said that they never used a library. Those who did use one were asked, "Can you always get from libraries the literature you want?"—a question phrased to encourage a critical response: 77% said they could, 12% said they could not, and 11% gave a qualified answer. If we bear in mind that the libraries used were in most cases small and, by the standards set by documentalists, not particularly well administered, the figures seem to show a remarkably low level of dissatisfaction. Other questions in the survey gave much the same impression. Thus, to the question, "Do you have any difficulty getting any source of information?", as many as 71% said "None". This hardly seems to support the documentalist's picture of the scientist

TABLE III

Source of ideas	*Per cent of responses*	*Per cent of respondents**
Written material of any kind	33	60
Intuition, thought, "myself"	23	40
Personal contacts	19	34
Observation† or experiment	13	24
Lectures, meetings—formal contacts	5	9
Trade exhibitions	2	4
Requirements of job or of customer	1	2
Other, can't say, etc.	4	6
	100	179

* Many respondents gave more than one source.
† Includes observation of other firms' products, processes, etc.

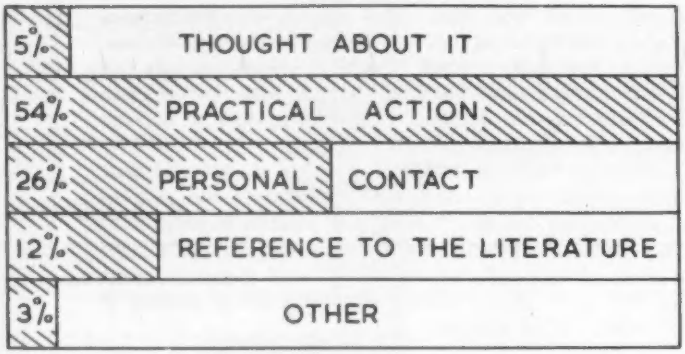


FIG. 4. The technologist's first step in dealing with a problem.

desperately trying to inform himself of the work of others in his field, but baulked by an inefficient library service, which has itself succumbed to the relentless exponential increase of incoming matter.

This kind of discrepancy suggests that a false assumption has been made and more evidence is needed. We may begin with Fig. 4. Respondents were asked whether they were currently working on any problem. Those who said yes were asked to describe it, and then to say what was the first step they took to deal with it. As a first step, 12% of respondents referred to the literature. The same question was asked for the second and third steps, and the percentage referring to the literature fell still further. Finally, the last step (presumably a typical one) showed only 2% referring to the literature.

A similar picture is painted by the answers to the question, "Can you recall the most recent article in any paper, journal, pamphlet, etc., that was of direct use or special interest to you?" As many as 29% could recall no such article. Those who could were then asked how their attention had been drawn to the article: 41% said that they came across it by chance, and 30% that they had a personal recommendation to it.

Finally, let us look at the answers to the question: "Can you say by what means you get most of your ideas, or stimulation for new ideas, for improvements or for new methods?"

In contrast to the earlier figures we now find literature jumping to first place. Is there any single thread running through all these results? We have seen that the amount of technical reading is small, that use of libraries is slight and few technologists are conscious of shortcomings in the libraries they use, that much technical reading takes place at home, that many technologists cannot recall anything of direct use that they have read, that most of those who can either came across it by chance or had it personally recommended by a colleague, that the literature is very little used to solve current problems and yet is claimed as the chief source of ideas. How are these findings to be reconciled?

One hypothesis seems to reconcile most of the anomalies: *the technologist reads technical literature mainly for interest or news; only rarely does he consult it to find a specific piece of information.* If this is so (and other evidence which we have no space to quote points the same way), then it is easy to understand why so much technical reading takes place at home, and why the technologist seems to care so little about the elaborate reference service of libraries and abstracts which the documentalists are trying to offer him. He reads technical literature for essentially the same reason as the rest of us read magazines and newspapers—because he hopes he may find there something interesting, stimulating, or useful.

CAN MORE INFORMATION BE COMMUNICATED?

This conclusion may seem obvious enough to the working technologist himself, yet it has long escaped recognition by those who are trying to solve the problem of technical information. This may be because the problem has always been looked at from inside a library, and from this position the technical literature appears as a fund of information to be consulted by someone who has a question to ask.

It is, of course, an excellent thing that the documentalists are working so conscientiously to improve their services. Nevertheless, if these findings are correct it looks as if the crucial problem lies elsewhere. The problem is to place each piece of new information in a publication where the reader who needs it will come across it in the course of his everyday browsing, and to present it in a manner interesting enough to persuade him to read it. To do this demands a much greater knowledge of the scientific reader, in particular of who reads what and how the scientist's attention is best maintained. One thing we know already: the technologist (if not the pure scientist) is as often the victim of laziness and indifference as the rest of us; it is quite unrealistic to suppose that he will read what he needs no matter how it is presented, and that his only want is an efficient reference service which can find him any article he asks for.

If editors and writers of technical journals spent as much energy as the documentalists (or for that matter the advertisers) in studying the scientific reader, there might be a huge increase in the amount of relevant technical information communicated to each technologist. Meanwhile, until the results of an objective inquiry are available, they might do well to gamble on the following general assumptions. The technical reader is put off by small print and bad layout. He can be kept awake by frequent changes of presentation—graphs, diagrams, photographs. He is put to sleep by an impersonal style, passive verbs, long-winded expressions. He likes to know what an article is about before he reads it, and to be reminded of what it was about after he has finished it. Finally, he is more likely to read a short article than a long one. Any article as long as this one should be ruthlessly cut.

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[1] "Interpersonal Factors in Research", University of Michigan, 1953–7.

[2] Halbert, M. H., and Ackoff, R. L., "An Operations Research Study of the Dissemination of Scientific Information", *Proceedings of the International Conference on Scientific Information, 1958*, Washington, D.C., 1959.

[3] Social Survey Report No. 245, "The Use of Technical Literature by Industrial Technologists", London, Central Office of Information, 1959.

SKYLARK
A HIGH-ALTITUDE RESEARCH ROCKET

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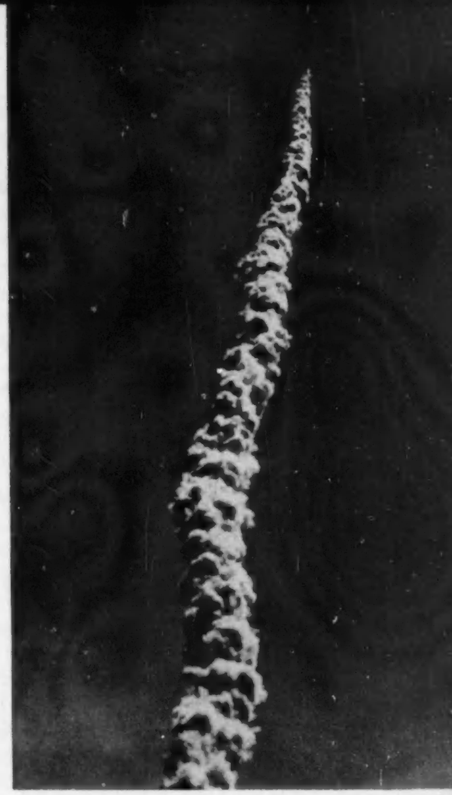
FIGS. 1 and 2. Smoke-trails from *Skylark*.
(Photographs by courtesy of Ministry of Supply, Royal Aircraft Establishment)



A few years ago it might have seemed necessary to preface this article with an explanation of the need for high-altitude research. Today, with satellites an accomplished fact, and space-travel a real possibility, the reasons are self-evident. What exactly is the structure of the atmosphere above us, how far does it extend, what is the intensity of the sun's X-ray emission? No longer are these questions and many others of academic interest only; they are now being asked by rocket designers faced with practical problems, which must be solved within the next few decades if the next step from satellite to space-travel is to be made.

It would be wrong to suggest that rockets alone supply the answers. Far from it. The greater part of knowledge about the upper atmosphere has been obtained from routine ground-based observations carried out over years of time. The special task of the research rocket is to make the occasional direct observation which will confirm the findings of the indirect methods, and sometimes to observe phenomena which can never be seen from the ground.

THE *SKYLARK*

The *Skylark* is the first British rocket to be used in upper atmosphere research. It is fired at present from the Woomera rocket range in South Australia. At 9.22 p.m. on November 13, 1957, *Skylark* No. 4 was fired into a clear night sky, carrying a payload of telemetry, tracking equipment, pressure gauges, eighteen flash and bang grenades, fourteen cartridges of metal foil and an ionospheric experiment. After launching at a steep angle the rocket accelerated to 3400 m.p.h. at 80,000 ft., and then coasted on upwards. At 110,000 ft. a timing switch fired the first grenade, the remainder following at regular intervals to 270,000 ft., with two clouds of metal foil interspersed. Instruments in the rocket and on the ground recorded the bursts of the grenades giving information on the temperature at each level. Radar tracked the clouds of metal foil to measure high-level winds. The ionospheric experiment, using a special insulated tip to the rocket nose, measured electron densities in the lower ionosphere. Ram and cone wall pressure gauges recorded the rapid fall of pressure with height, detecting the small pressure fluctuations as the rocket rolled and yawed, the results being telemetered continuously to the ground. Three minutes after launching the rocket was at the peak of its trajectory, nearly 80 miles high; after six minutes it had fallen to the ground 110 miles downrange. Many months will have gone by before the great quantity of results obtained during these few minutes has been reduced and interpreted.

Skylark is a simple, fin-stabilised rocket. The most important single feature in its construction is the *Raven* solid propellant motor, 15 ft. long, 17 in. diameter. For economy, simplicity of operation, and ease of handling it stands well ahead of contemporary liquid fuel motors. The *Raven* motor forms the main body of *Skylark;* the entire payload is carried in two nose compartments attached to the front of the motor and three fixed fins are secured to the rear (Fig. 3). There is no guidance system; instead the rocket is projected from a very long launching-tower (Fig 4) which sets it on its predicted course, with due allowance made for the effect of winds.

The rocket nose cone, which forms one of the two instrumentation compartments, is made of 20-gauge stainless steel to withstand the severe aerodynamic heating; cone temperatures as high as 500°C may occur. The remainder of the nose structure is cast in light alloy units, these being

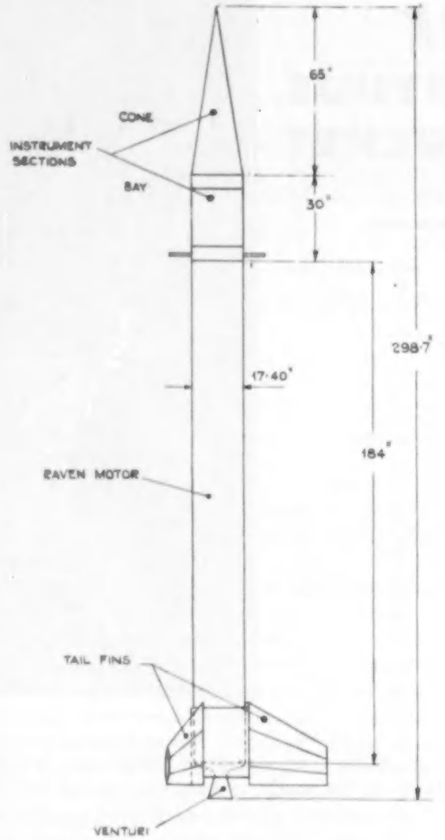


FIG. 3. Schematic drawing of the *Skylark* rocket.

so designed that the compartments may be changed or added to, to suit a variety of requirements.

FLIGHT INSTRUMENTATION

Two methods of tracking the rocket in flight are used, one measuring velocity and path length, the other measuring position. A continuous signal transmitted from a ground station, is received by the rocket, doubled in frequency and returned to the ground. Owing to the velocity of the rocket the frequency of the returned signal is modified (Doppler effect) and when mixed with the original signal a beat frequency results which is a measure of the rocket velocity. The total number of beats is a measure of the path length. If three widely spaced ground receivers are used, a complete and accurate trajectory can be computed to at least 200,000 ft. altitude. Beyond this height the rocket can be assumed to be in a vacuum, and the remainder of the trajectory is calculated quite simply.

The other tracking system employs a 6 cm. beacon in the missile, which radiates a continuous signal; this is followed by auto-tracking radars on the ground throughout the flight. A real-time presentation of missile position is made on plotting-tables for immediate information, and a photographic record of the radar scales is later used to give tracking data of much higher accuracy.

In-flight measurements are returned to the ground by telemetry. Twenty-three separate inputs are transmitted by a single information channel, each input being sampled 80 times per second by a high-speed multi-way switch. Where a lower information rate can be tolerated further sub-switching is used to provide yet more channels. The sampling rate of 80 per second sets a maximum limit to the frequency response of a sub-channel. The use of several channels for one input raises this limit, at the expense, of course, of the total number of inputs, but where very high-frequency information is required the high-speed switch cannot be used at all. When vibration measurements are being made with barium titanate crystals for example, signal frequencies up to 2 kc/s must be transmitted by using the telemetry as a single-channel sender exclusively.

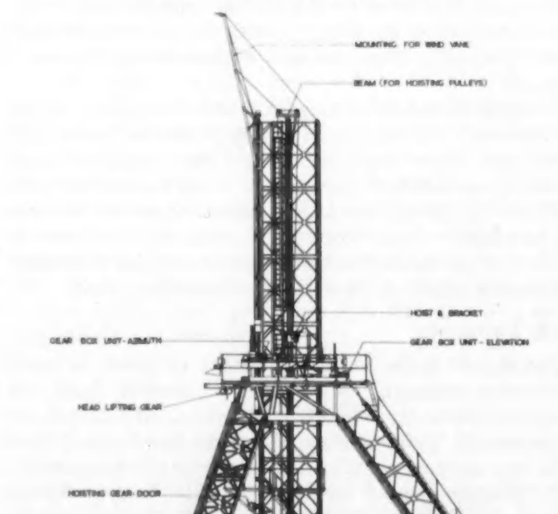
Power supplies are obtained from silver-zinc accumulators, and rotary converters generate the high-tension supplies. By using specially developed accumulators with very high discharge rates and by over-running the rotary converters the weight of the power supplies is kept low. Transistorised circuits are introduced wherever possible to keep down the power demands. Potting of all circuit components, except radio valves, in epoxy resins is a standard procedure, and is extended to include dry batteries which have far greater storage life times as a result. Radio valves are mounted in metal blocks to prevent overheating.

PERFORMANCE

The performance of *Skylark* in terms of maximum velocity, height at maximum velocity, peak height, and range, varies with the mark of *Raven* motor, the payload, the all-up weight at launch, the drag of the particular missile and the angle of launch. The aim when the original design was made was to carry a payload of 100 lb. to an altitude of 100 miles with a single-stage vehicle.

Six development versions of *Skylark* were made initially, and firings were begun in February 1957, at the Australian

FIG. 4. Launcher for *Skylark* rocket.



rocket range at Woomera. The angles of launch were low at first, being increased as experience was gained (Fig. 5). In the table below we give the predicted and actual performances of *Skylark* No. 4 fired on November 13, 1957 using a *Raven IA* motor. For comparison the predicted performance of *Skylark* No. 8 is given; the payload will be identical with *Skylark* No. 4, but the rocket will carry fins some 60 lb. lighter and will use a *Raven II* motor. The *Raven IA* and *II* motors are identical in total impulse, but the *Raven II* has a higher initial thrust.

TABLE I

	Skylark No. 4		*Skylark No. 8*
	Predicted	*Actual*	*Predicted*
Weight at launch	2550 lb.	2605 lb.	2550 lb.
Payload (approximate)	80 lb.	130 lb.	130 lb.
Effective angle of launch (Q.E.)	85°	84°	85°
Maximum velocity	5047 ft./sec.	—	5384 ft./sec.
Height at all-burnt	80,600 ft.	—	99,000 ft.
Peak height	82·5 miles	77·3 miles approx.	98·5 miles
Time at Peak	189·9 sec.	—	201·6 sec.
Range at impact	99·3 miles	108·8 miles	79·1 miles
Change in peak height for degree change in Q.E.	2·8 miles	—	1·5 miles

Performance predictions are made well before a firing, covering a number of different all-burnt weights and angles of launch. Trajectories are calculated step by step on an electronic digital computer using a knowledge of missile drag and its variation with Mach number, motor thrust and its variation with time, and the variation of atmospheric pressure and density with height. Particular attention has been paid to calculations of the initial phase of the ascent when wind effects are most marked, and the detailed predictions of the rocket's response to wind conditions made from these calculations have been fully confirmed by the Woomera firings.

The maximum height of a rocket can be increased by the use of a small tandem boost motor, which operates for a few seconds after launch and then falls away. In addition uncertainty in performance resulting from errors in wind prediction is reduced by increasing the launch velocity with a boost motor. For both these reasons the *Cuckoo* boost motor has been developed for use with *Skylark*, and it will raise maximum altitudes to 750,000 ft. or more.

GROUND INSTRUMENTATION

The firing of a comparatively complicated rocket such as *Skylark* requires the support of a large and well-equipped firing range. For this reason the firings of *Skylark* are restricted to the Woomera and the Aberporth rocket ranges. The main items of ground instrumentation are concerned with the tracking facilities already described, and with the telemetry ground receivers which are large and intricate installations. They receive the telemetry signals, demodulate them and then record a so-called "histogram" of twenty-three repeated information levels on high-speed 35 mm. film, later to be read and plotted, by hand or machine. In addition, while the missile is in flight, the ground equipment separates the information levels into twenty-three channels, by means of a synchronisation pulse derived in the missile from the high-speed switch, and a low-speed record of these separated outputs is photographed from C.R.O. displays in real time. In this way a ready-to-read record of each information channel is available shortly after a firing (see Fig. 6); it is examined for events of particular interest, and these are then analysed in detail from the high-speed record.

Optical tracking plays a large part in flight trials. High-speed cine-cameras and cine-theodolites are sited at strategic points on the range boundaries; the former record

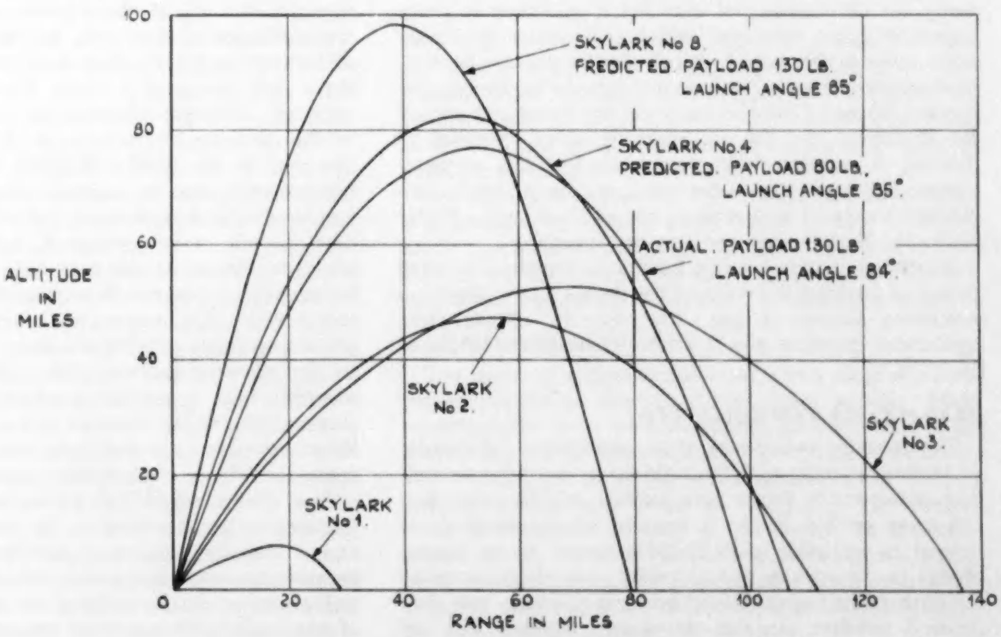


FIG. 5. Trajectories for *Skylark* rocket.

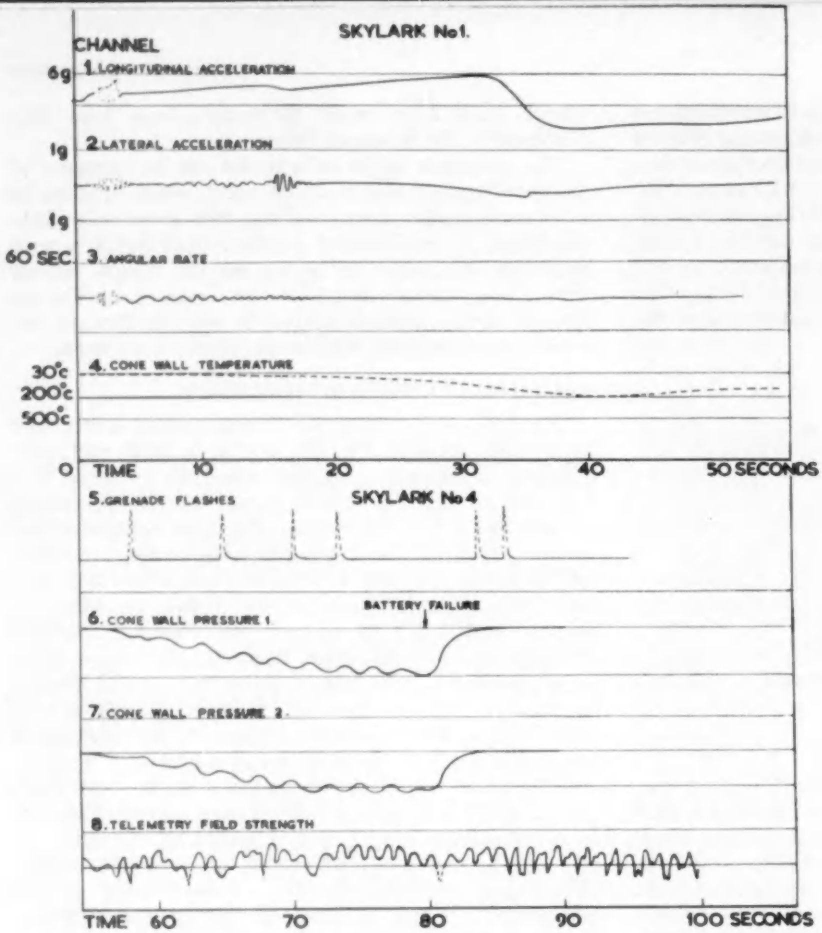


FIG. 6. Typical telemetry records from *Skylark* rocket firings. The Pirani pressure-gauges in channels 6 and 7 were on opposite sides of the cone, and the pressure modulations due to roll are out of phase.

missile behaviour in the early stages of flight, the latter enable missile position to be found with considerable accuracy to high altitudes.

The first *Skylark* firings have so far relied upon telemetry for the recovery of data but a parachute recovery system is being developed which will return the rocket head safely to the ground. It will then be possible to carry photographic or magnetic tape recorders in the rocket. The head is released from the motor on the downward part of the trajectory, and the air gradually slows its speed of descent. A pressure switch operates at 30,000 ft. or thereabouts, causing a gun to fire out a drogue, which in turn steadies the head and deploys the main canopy. Radar tracks the final descent, and recovery is rapid.

A penalty is paid for this facility, of course. For each pound of payload in excess of the design figure 800 ft. in maximum altitude is lost. Forty-five lb. of parachute equipment therefore means a loss in maximum height of 36,000 ft.

FLIGHT MEASUREMENTS

The pressure and density of the atmosphere fall rapidly as *Skylark* ascends; with the build-up in speed the controlling aerodynamic forces first increase rapidly, and then fall away until a height is reached where aerodynamic control is negligible. Ideally there would be no further change in the *attitude* of the rocket; it would continue to the peak of its trajectory still pointing upwards, and then descend tail-first. In fact this rarely happens with an uncontrolled rocket. Usually it is rolling slowly, and precessing like a top running down as it leaves the lower atmosphere. Sometimes it turns head over tail with a quite random motion. This changing attitude during flight through the upper atmosphere can effect experimental measurements considerably, and for this reason methods of measuring attitude have been devised, so that corrections can be applied when experimental results are analysed. External references are required, and these may be the direction of the horizon, Sun, Moon, Stars, Earth features, or the Earth's magnetic field. The Sun is an obvious reference in daytime flights, and the Earth's magnetic field is convenient, even though difficult to use. *Skylark* will carry groups of three orthogonal photosensitive surfaces in the nose wall, each surface giving a cosine response to the flux of sunlight reaching it as the rocket rolls. The outputs are telemetered to the ground, and the variation of the Sun's vector with time with respect to the rocket calculated. The direction of the Earth's magnetic field is measured with flux-gate magnetometer elements to give the variation of a second vector with time. When two reference directions have been determined the complete attitude of the missile can be found.

The measurement of pressure is of fundamental importance in determining the atmospheric parameters, and it also has immediate aerodynamic application. If pressure measurements are made at both the ram and cone wall positions on the rocket cone, then from a knowledge of Mach number the ambient pressure can be deduced. In

practice it is found that the angle of attack of the rocket is seldom zero and two diametrically opposite wall gauges give different readings; in addition a modulation appears due to the roll of the missile. Nevertheless the information can be handled, and useful aerodynamic results obtained. The wide range of pressure encountered during a flight to 100 miles altitude poses a big instrumentation problem. No single gauge covers the entire range, and it is necessary to fly bellows gauges, Pirani gauges and ionisation gauges, making a heavy demand on telemetry channels and space. Pirani gauges were flown in *Skylark* No. 4, and ionisation gauges are being prepared for future firings.

GASSIOT PROGRAMME OF UPPER ATMOSPHERE RESEARCH

A joint programme of upper atmosphere research with *Skylark*, arranged between the Gassiot Committee of the Royal Society, and the Ministry of Supply, began in 1958. A comprehensive series of experiments has been planned by a number of British universities, in collaboration with the Royal Aircraft Establishment, and flight testing of equipment began in 1957. Amongst the special facilities being supplied in the rockets are a jettisonable nose cone, and a grenade bay from which explosive grenades and window cartridges are fired.

The firing of *Skylark* No. 6 on April 2, 1958, and the firing of *Skylark* No. 5, which reached a peak altitude of about 93 miles, on May 20, 1958, completed the initial phase of the development programme. The Gassiot upper atmosphere research programme began on April 17, 1958 when *Skylark* No. 7 was fired to about 91 miles altitude, carrying the grenade experiment for the measurement of temperatures and winds (University College, London), metal foil for the measurement of winds (Imperial College), and the insulated cone experiment for the measurement of electron densities (University of Birmingham). *Skylark* No. 9, carrying a similar payload, was fired at 00.45 hours on June 19, 1958, on the occasion of the IGY World Rocket Interval, and reached a peak altitude of about 103 miles. This rocket was almost identical to *Skylark* No. 8, the predicted performance for which is shown in Fig. 5 and Table I.

ROCKET VERSUS SATELLITE

What influence does the advent of upper atmosphere research with satellites have on high-altitude rocketry? There are, on the one hand, satellite vehicles operating up to altitudes of hundreds, even thousands, of miles, for flight times of months or years, continuing to give useful information even after the radio transmitters have ceased to operate. The cost is very high and recovery difficult. On the other hand there are rocket vehicles which can be operated up to a few hundreds of miles, and have very short flight times. Recovery is easier and the cost much lower. Both satellites and rockets can carry the same instruments. The question is—do we need to continue the operations with rockets, if satellites are equally capable of producing the sort of information we want, and in very large quantities commensurate with the great cost.

The answer must be that rockets will be used for all upper atmosphere research up to about 100 miles altitude, but only for certain special purposes above that altitude once large, well-instrumented satellites are in use. Satellites are unable to operate in the region below 100 miles because of the high atmospheric drag, yet this region is of great scientific interest. For instance it contains the whole of the E-layer of the ionosphere, which has such an influence on radio communications.

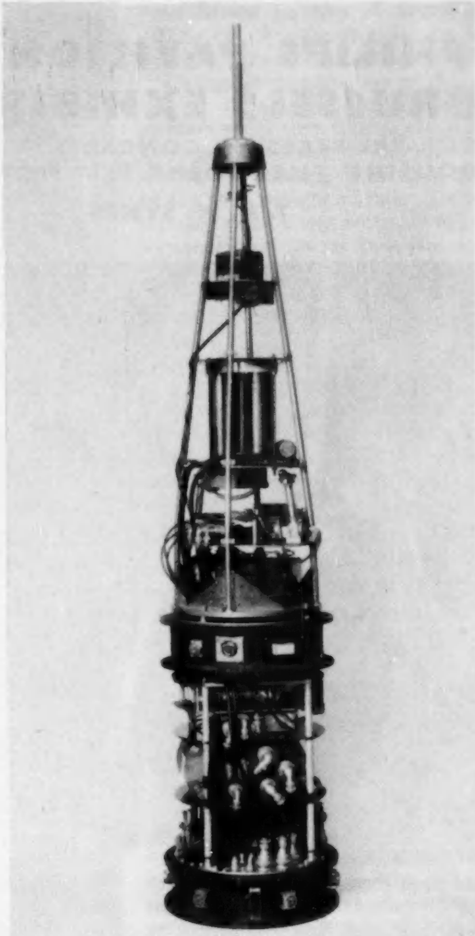


FIG. 7. Internal view of *Skylark* rocket.

For measurements above 100 miles it will be a matter of a decision, by those in a position to choose, whether a satellite or a rocket best meets the requirements of a given experiment, bearing in mind cost, payload space available, the nature of the experiment, and the need for recovery.

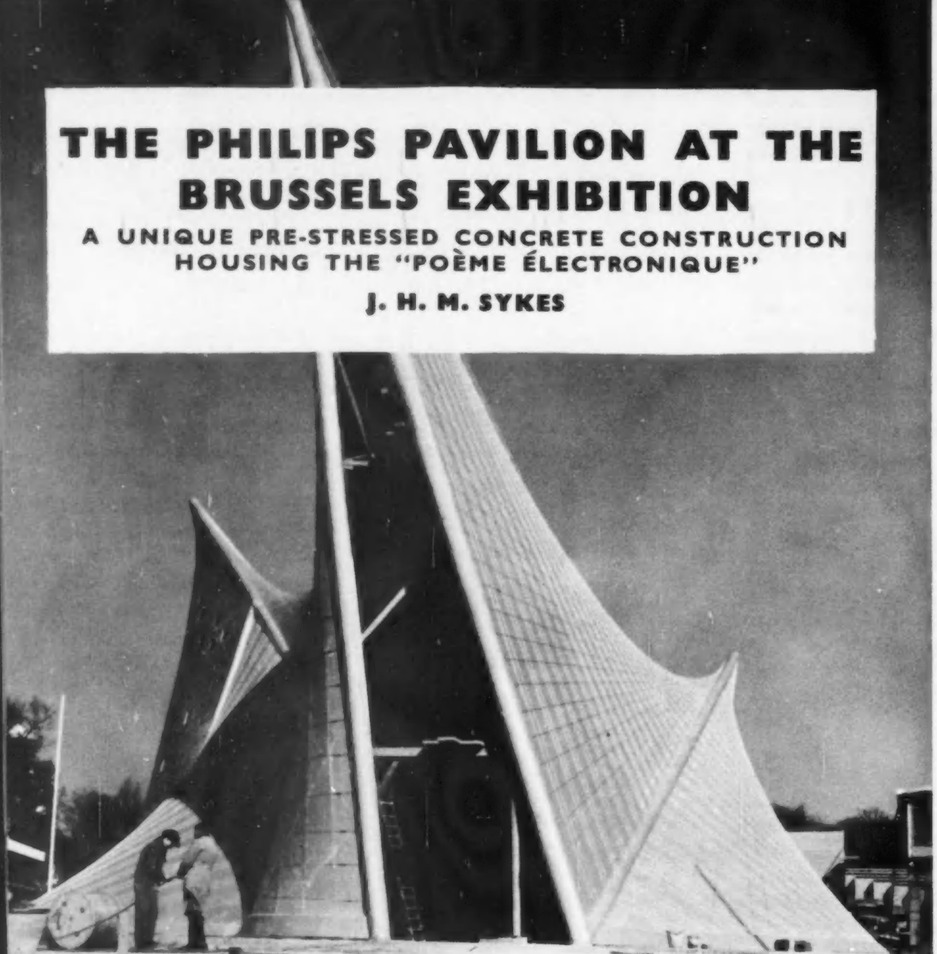
ACKNOWLEDGMENTS

The firing of a high-altitude rocket is a large and complicated operation involving very many people. Many manufacturing firms are concerned in the production of the rocket nose, motor tube, and instrumentation. The design and assembly of the rocket at Farnborough and the production of the *Raven* motor at Westcott is the work of many individuals, too many to be named. In Australia, where, in the Weapons Research Establishment, Department of Supply, the completed rocket is taken over, finally prepared and fired, many more people have contributed to the success so far achieved with *Skylark*.

THE PHILIPS PAVILION AT THE BRUSSELS EXHIBITION

A UNIQUE PRE-STRESSED CONCRETE CONSTRUCTION HOUSING THE "POÈME ÉLECTRONIQUE"

J. H. M. SYKES



It would need three-dimensional illustrations to do justice to one of the most striking architectural feats ever attempted —the Philips Pavilion at the International Exhibition at Brussels, which has recently closed.

The pavilion was designed for the basic purpose of providing a theatre for an electronic spectacle, produced entirely automatically, with specially written music and lighting effects. The fields of illuminating engineering, electro-acoustics, electronics, and automatic control were exploited to the full in the spectacle; but the first purpose of this article is to describe the structure itself, a unique example of pre-stressed concrete techniques.

The basic conception came from the Arts Director of the company, Mr L. C. Kalff; and the famous French architect Le Corbusier was commissioned to provide the design, in which he collaborated with another architect, Mr Y. Xenakis.

A STRUCTURE MADE FROM RULED SURFACES

It was proposed that the pavilion should be a structure made up entirely of ruled surfaces, in the form of the geometrical construction known as hyperbolic paraboloids; and after several initial designs had been considered Le Corbusier and Xenakis commenced the final design by using two straight metal spokes joined by a system of elastic strings fixed at equidistant points along each spoke. These strings formed the ruling lines of the shape of the structure, the geometry of which was determined by the distance between the spokes, the angle between them, and the position of two arbitrary strings.

The three peaks so created were then moved slightly to provide a more harmonious proportion for the complete structure. The height of the highest peak was 21 m., the next highest 18 m., and the lowest 13 m.

The next problem was to consider how such an unusual structure could be constructed in practice. The firms who were asked to quote in the main suggested conventional constructional methods, some proposing double-walled shells, either of wood, metal, or plaster, having thicknesses up to 80 cm. and embodying complex skeleton structures. However, a Belgian contracting firm under the direction of Dr H. C. Duyster evolved a proposal more in accordance with the originality of the architects' ideas. Dr Duyster's scheme was to build the pavilion as a shell structure of pre-stressed concrete with a thickness of 5 cm.—the thickness which in any case had been imposed as a minimum to provide adequate soundproofing. He proposed that within the structure there should be a few stanchions to give the walls some additional support, but in the main the hyperbolic parabolas, known as "hypar" shells, were to be self-supporting when joined by the pre-stressing wires to the main ribs on the intersection lines. In this feature of the design lay the main facet of originality: nothing of this kind had been attempted before.

It was decided to award the contract to Dr Duyster's organisation, and in the course of collaboration between him and the architects a slight change in the general layout enabled the shell intersections to play the part of strengthening stanchions, and thus it was possible to avoid any internal supports of any kind, greatly enhancing the internal appearance.

EVOLUTION OF TESTING METHODS

It was necessary to prove conclusively that such a structure would be safe against buckling or movement of any kind, under the influence of settling of the ground, wind pressures, or snow loading. Thus the constructional firm approached Prof. Vreedenburgh for suggestions as to testing methods to ensure that all the necessary safety conditions were fulfilled.

It was found that mathematical analysis of stresses could not be applied to so complex a structure, and that scale-model tests would form the only reliable method. The Netherlands Institute for Building Materials and Building Constructions prepared a model on the scale of 1 : 25, made up of plaster of Paris on a framework of wire gauze. This complex model was constructed and tested in a single week.

Tests were carried out by the aid of a large loading frame so that the model was loaded by its own weight, by a vertical load on a single, nearly horizontal, surface (to investigate snow loading), and by wind pressures on each separate surface. Some forty displacement gauges of the dial type were used, and strains were measured by means of forty strain gauges for the preliminary tests and 130 gauges for later tests.

The extreme values of the forces in the ribs, both tensile and compressive, were found to be about 30 tons, while the extreme values of the stresses, partly caused by bending, amounted to -60 kg./cm.^{2} and $+80$ kg./cm.^{2}. The tests enabled the amount of pre-stressing that would prove to be necessary to be ascertained.

The next problem to be solved was that

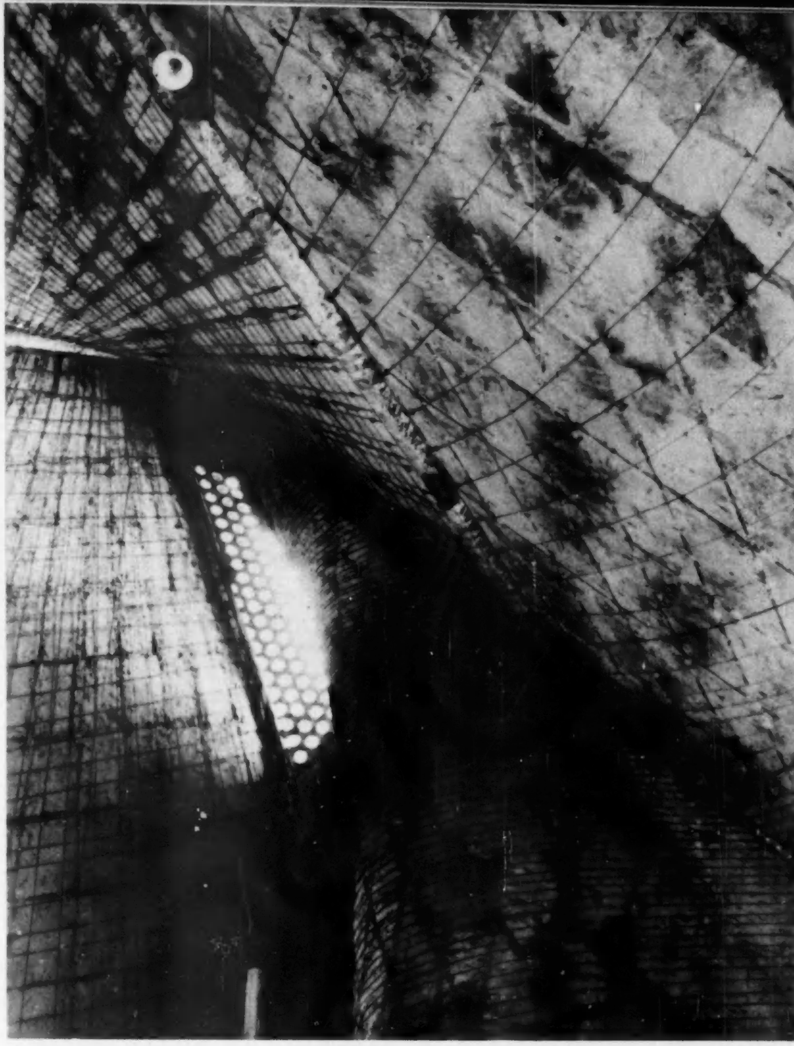


FIG. 1. Part of interior of the pavilion. The pre-stressing wires on the concrete, which enhance the plastic form of the structure, are unfortunately concealed in the finished pavilion by a surfacing required for the projection of colours and pictures.

of the actual construction. The firm concerned, Strabed, decided to build up the shell surfaces from pre-cast slabs, which were first to be erected on scaffolding and then held together by pre-stressing wires. A complicating factor was the need, as first envisaged, to arrange the pre-stressing wires on the inside of the building only. It was felt that although the pre-stressing forces would apparently be applied eccentrically, nevertheless they would be exerted, in practice, centrally within the shell surfaces.

AN ELABORATE SCALE MODEL

In order to try out the constructional method under conditions as near as possible to those of the actual job, a model on a scale of 1 : 10 was constructed, and part of the whole pavilion was built up in this way. Plywood slabs were used, bent to the appropriate shape, each having an area of approximately 100 sq. cm. Pre-stressing was carried out by using pre-stretched nylon thread.

During the construction of this model it was found that those ribs of the pavilion which were free on one side were eccentrically twisted by the pre-stressing action, and buckling occurred in one part of the steep upright surface. To prevent this happening it was necessary to provide torsional moments on these ribs equal in magnitude to those which would result from the pre-stressing of the abutting surface, which was not present in the model.

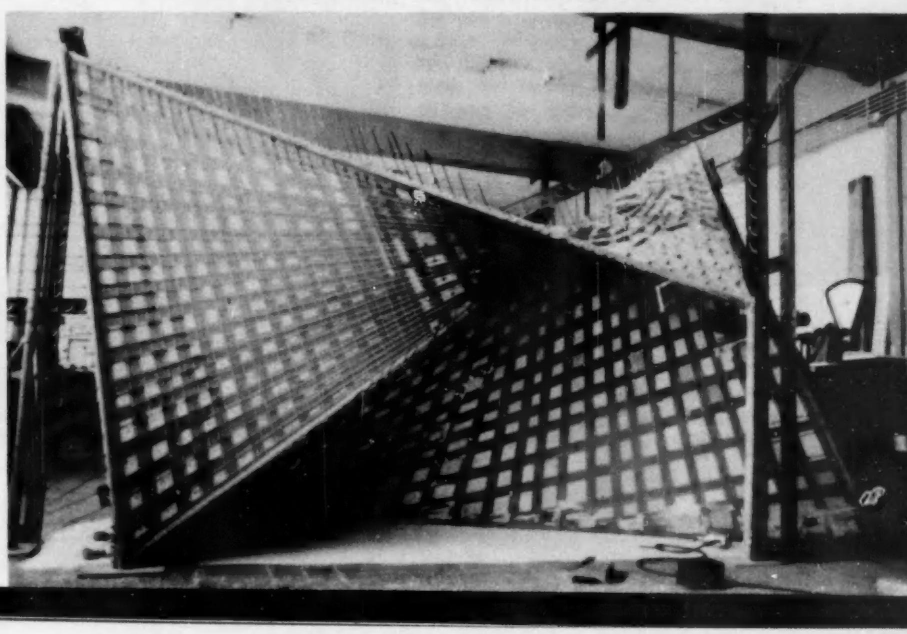
The model was subjected to a load corresponding to its own weight plus the wind force, and these tests showed that certain stiffening members, in the form of additional ribs, had to be provided to make quite certain that the structure would withstand all conceivable loads to which it might be subjected in practice.

INGENIOUS CONCRETE MOULDING METHODS

After all these tests the actual construction work commenced. The concrete used was cast to the peculiar shapes necessary by an ingenious system of building up beds of sand to the required shape to make some dozens of slabs. The sand was then covered with a thin skin of cement, and slats of wood were laid over its surface to divide it up into the appropriate areas to make the slabs. The slabs were then cast to a thickness of 5 cm. and were provided with a light, reinforcing mesh to prevent breakage during transport to the site. The approximate size of each slab was about 1 sq. m.

The ribs were of circular shape, and were cast *in situ* in shuttering mounted on a framework of wooden struts and stays.

FIG. 2. The 1 : 10 model for investigating the system of construction planned by Messrs. Strabed (Stevin Laboratory, Technische Hogeschool, Delft).



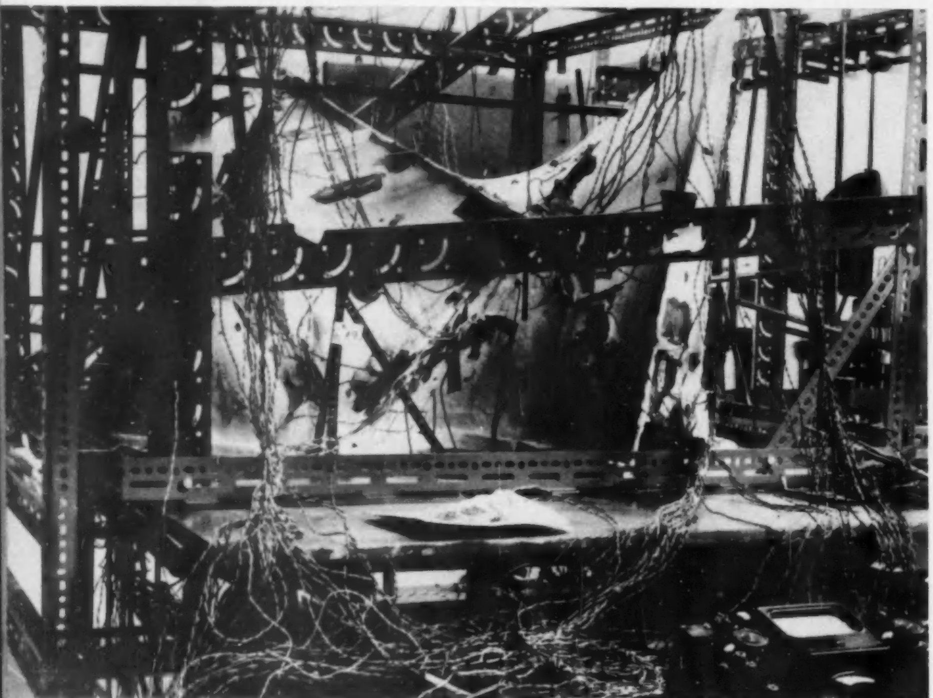


FIG. 3 (*Above*). Equipment used for measurements on the plaster model. A series of displacement dial-gauges are mounted on angle struts and connected via long rods to the model. A large number of strain gauges are fixed to the shell surfaces and the ribs for determining the stresses (hence the elaborate wiring). Some of the indicating instruments are visible in the foreground.

FIG. 4 (*Below*). The plywood model during the application of a load corresponding to the deadweight of the structure.

For the actual construction of the pavilion, wooden scaffolding was erected with the outer surface beams following the ruling lines of the surfaces of the structure. The slabs were then placed in position and held temporarily in place while mortar was added in the joints. The pre-stressing wires were so arranged as always to take a straight line. The steel wires used were of 7 mm. in diameter and were laid over the surface and post-tensioned, thus holding the slabs together It was finally decided that they were to be applied to both internal and external surfaces.

The ribs were pre-stressed in three distinct directions. First, compressive pre-stresses were produced so that the ribs could take up the tensile stresses; and secondly, some ribs were given a bending pre-stress by means of wires following a parabolic path in a plane through the axis. Third, torsional pre-stresses were introduced in a number of ribs to counteract the torsional moments imparted to them by the pre-stressed shells on which they abutted.

SPECIAL PRE-STRESSING JACKS

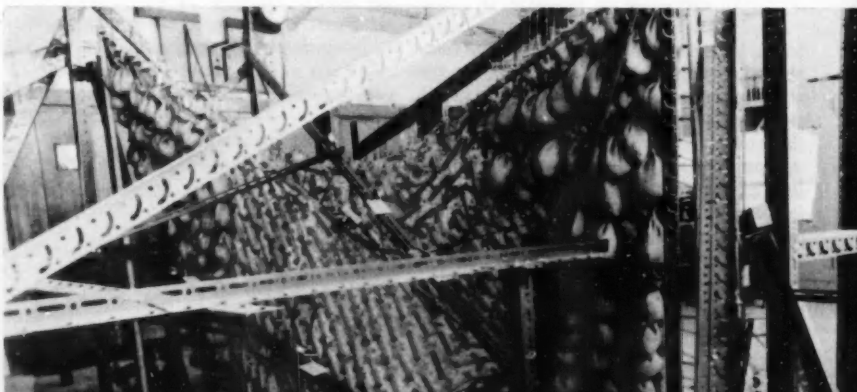
The pre-stressing of the wires was carried out by having the anchoring wires cast in the ribs and into the sub-structure of the shells at ground-level. Each wire was threaded through a small steel anchor plate, and crimped at each end. The pre-stressing wires were coupled to the anchoring wires by specially designed sleeves so that no slip could occur. The wires were then tensioned with a special jack designed by the company, to grip the wires from the side; and the amount of tensioning to be applied could be read accurately from a dynamometer fitted to the jack. The wires were so arranged as to be 2–3 cm. from the shell, and did not intrude on the general appearance of the façade.

The striking success of this novel project points the way to the use of shells, made up of "saddle" surfaces, for other purposes—for example, for the roof members of large halls. It may well be that the Philips Pavilion at the Brussels Exhibition will be the forerunner of many other buildings similiarly designed, providing lightness, grace, beauty—and at the same time economy in materials.

THE "POÈME ÉLECTRONIQUE"

The spectacle which this unique pavilion was designed to house was just as startling in its impact on the audience as the pavilion itself. It was basically designed as a *Poème Électronique* which, in the words of the architect, Le Corbusier, was intended "to show, in the midst of an anguishing tumult, our civilisation out to conquer modern times".

It would be out of place in a scientific journal to attempt an appreciation of the artistic merit of the performance, which was variously applauded and detested by the millions of viewers who ultimately saw it and heard it during the course of the Exhibition. One experienced musical reviewer said "the total effect was beyond description". We therefore propose to content ourselves with describing the light and sound effects employed from the



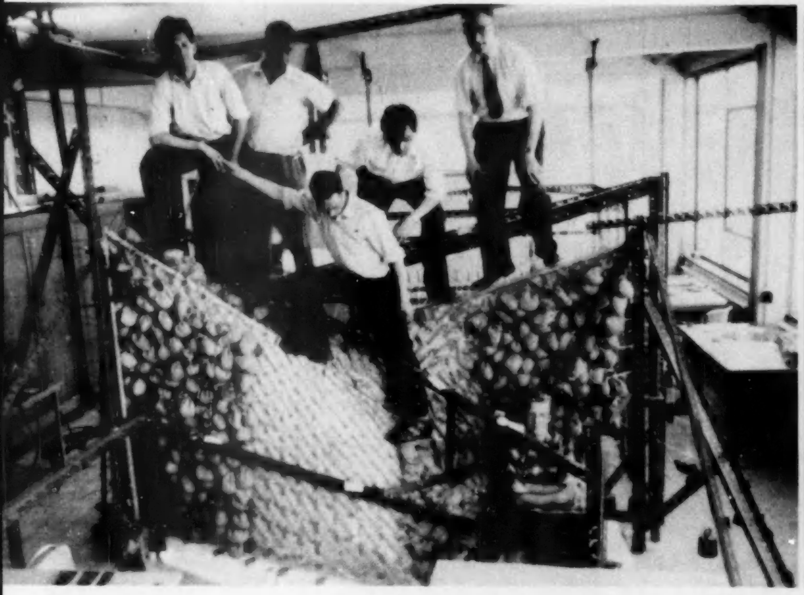


FIG. 5. The plywood model severely overloaded.

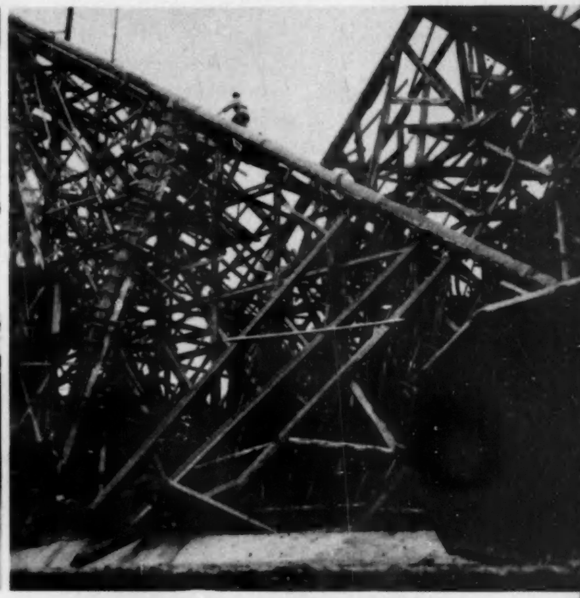


FIG. 6. The 40-cm.-thick cylindrical ribs were cast *in situ* in "shuttering" erected on scaffolding.

technical point of view, together with the electronic control system.

The curved walls of the interior of the pavilion were used as screens on which there was a continuous movement of projected pictures and colours, accompanied by electro-acoustical effects of a very wide variety. The programme lasted eight minutes, and was produced entirely automatically by means of pre-recorded magnetic tapes.

FIVE TYPES OF LIGHT EFFECTS

The light effects were divided into five categories. First there were illuminated surfaces with coloured light conjuring up particular atmospheres. Then there were figures suspended in space treated with fluorescent paint and irradiated as required with ultra-violet light to glow in various colours. Next came the large areas of walls on which pictures of various scenes were projected. Then there were the "Tritrous", as they were called, an ingenious arrangement whereby beams of light very sharply defined in character ended by projecting figures or coloured spots on various parts of the wall. These effects were achieved by means of film strips with each frame entirely opaque except for three holes (from which the word "tritrous" is derived) in which the colours or figures were introduced.

To project these colours as required by the plot, four large cinema projectors (two of them for the pictures and two for the tritrous) were used, and these were synchronised by means of magslips, a form of electromagnetic control linking two or more rotating shafts. Four projection lanterns with 3-kW lamps fitted with rotary discs actuated by servomotors, were employed for the ambiances or floods of colour. Projection lanterns were used for producing cloud effects or for projecting a sun and a moon. Spotlights with 500-W lamps assisted in projecting the ambiances, and four 125-W high-pressure mercury vapour lamps were used for the provision of ultra-violet light. In the upper surfaces of the walls there were fifty 5-W incandescent lamps to give the effect of stars, these being switched on and off in an irregular fashion by means of telephone-type selectors. Behind a balustrade following the contour of the floor there were forty groups of five fluorescent lamps in white, red, yellow, green, and blue. These lamps were used to create the illusion of a bright horizon, and were dimmed by means of thyratrons, in accordance with a pre-determined lighting plan.

In addition to these lighting installations there was also an emergency installation operated from a battery in case of failure of the main power supply.

THE "COMPOSITION" OF THE MUSIC

The sound aspect of the performance related to the production of an electronic poem composed by Edgar Varèse. This music was largely of the "Music Concrète" type. In this type of music much of the sound is entirely artificially created; for example, an electronic impulse transmitted to a recording tape is then replayed at a different speed with electronic additions of overtones to create a sound never before heard. A description of the sound-effects, by W. Tak, in *Philips Technical Review*, 1958, vol. 20, No. 2/3, says that "the composition is characterised by an extraordinary wealth of sounds, the realisation of which often involve considerable difficulties. . . . Varèse frequently indicated his wishes by such expressions as 'more nasal', 'less biting', 'more rasping', and it was our job to meet his wishes as well as possible by means of filters, mixers, and frequency shifting circuits. To define the necessary operations we had to resort repeatedly to onomatopoeic words such as 'wow wow', 'poowhip', 'tick tock', 'whoop', and 'choochah'." The original music was recorded on a three-track tape, two of the tracks being used for reverberation and stereophonic effects.

The control of the lighting effects and of the distribution of sound from the groups of loudspeakers, totalling 350 in all, was carried out by means of a fifteen-track magnetic tape, both this tape and the music tape being of 35 mm. in width, and being perforated as for cinematograph film, to ensure that synchronism between the two could be attained.

The music was distributed by means of twenty-five low-note loudspeakers fitted in one of the walls, behind the balustrade. The remainder of the 350 speakers were fitted in compact groups over the entrance and exit and in dispersed groups all over

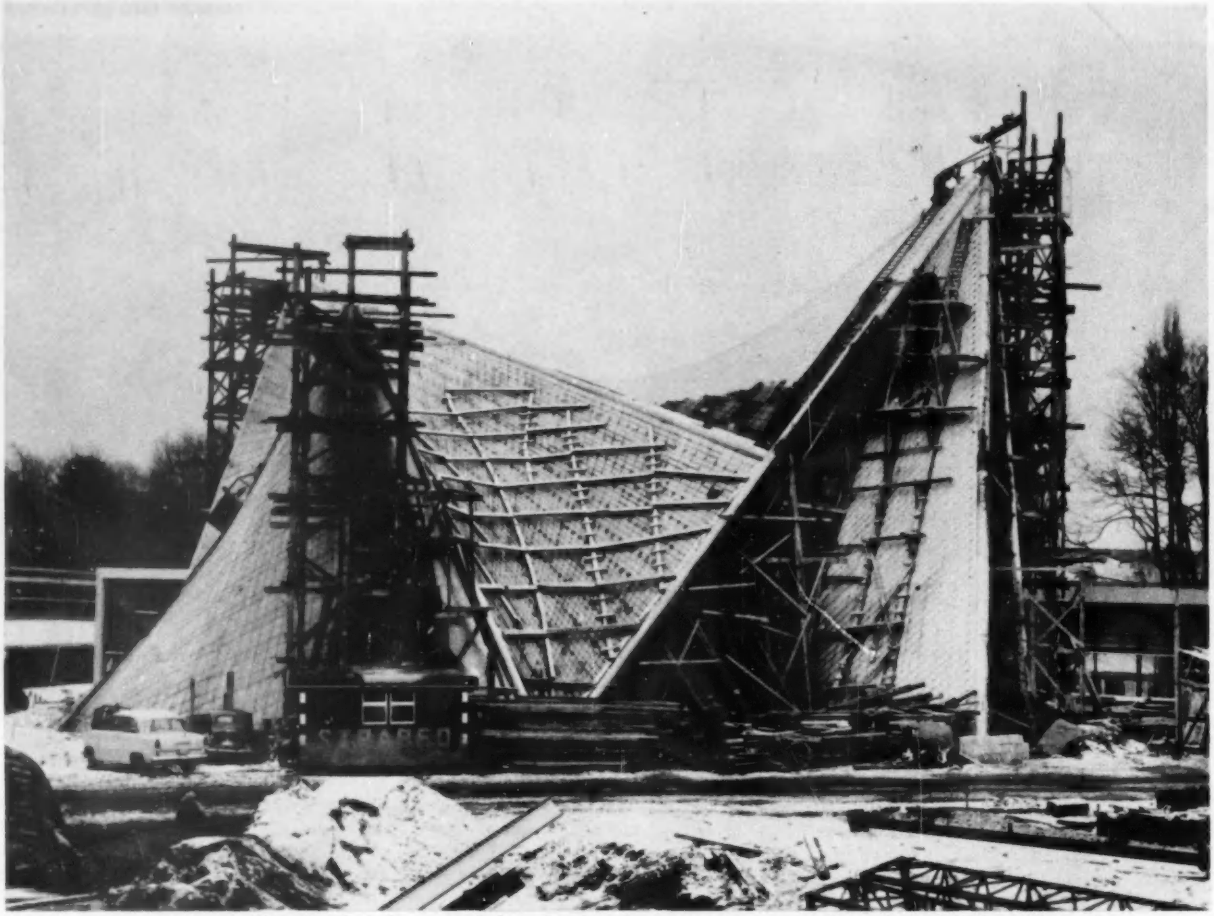


FIG. 7. The pavilion shortly before completion, showing the numerous pre-stressing wires of high-tensile steel which are applied to both surfaces of the shells. Each wire is 7 mm. thick and is tensioned with a force of 3300 kg.

the interior surface. In this way, "sound routes" could be envisaged. By relaying a particular sound to loudspeakers situated along a particular route, in turn, the sound could appear to move, just as an electric news sign appears to cause the lighted lamps to move across the screen, when in reality they remain stationary and become illuminated in sequence. A total of twenty amplifiers, each with an output of 120 W, was used.

Each of the fifteen tracks on the control tape could carry twelve control signals, each with a fixed amplitude and a fixed frequency which differed from one signal channel to another. In this way no less than 180 control channels became available, by using filter circuits to separate the signals on each channel from each other.

THE 180 CONTROL CHANNELS

The output from each of the 180 control channels was taken, as appropriate, to the control of loudspeaker groups or to controlling the lighting circuits. In the case of the loudspeaker groups, telephone selector relays were used with an ingenious relay circuit which avoided the enormous multiplication of relays which would otherwise have been required.

In this circuit, rectifiers are used in such a way that, for example, three relays can be connected together, with three terminal points to the network, in such a way that current applied to the first terminal will energise one relay, to the second point two relays, and to the third point all three. Any other arrangement would have required a very considerable number of subsidiary relays.

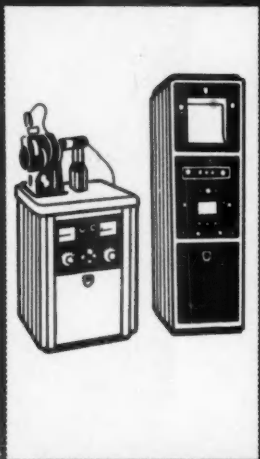
By control signals co-ordinated to the most exact degree possible with the musical score, relay systems such as that just mentioned could direct the sound in any required fashion. The whole characteristics of the sound could be altered, from reverberation effects as in a large empty space down to thin sounds as created in a small, soundproof room.

The lighting control signals from the tape were taken through relays to servo-motors which controlled the phase-shifting devices attached to the grids of the thyratron valves, which dimmed the lighting circuits as required or operated the colour-changing discs on the projection lantern.

The whole of the equipment for control purposes was duplicated, and alternate performances were given on each of the two equipments. In this way not only was there security against breakdown, but in addition the performances could be given continuously, avoiding the delay required by the rewinding and realigning of the three-track and fifteen-track control tapes.

The amazing effect produced by this equipment is an example of advanced electronic techniques applied to artistic purposes to an extent never before realised.

(We are indebted to N. V. Philips' Gloeilampenfabrieken of Eindhoven, Holland, for the illustrations, and for the technical data on which this article was based. Philips Technical Review, 1958–9, *vol. 20, Nos. 1 and 2/3 are entirely devoted to this subject.)*



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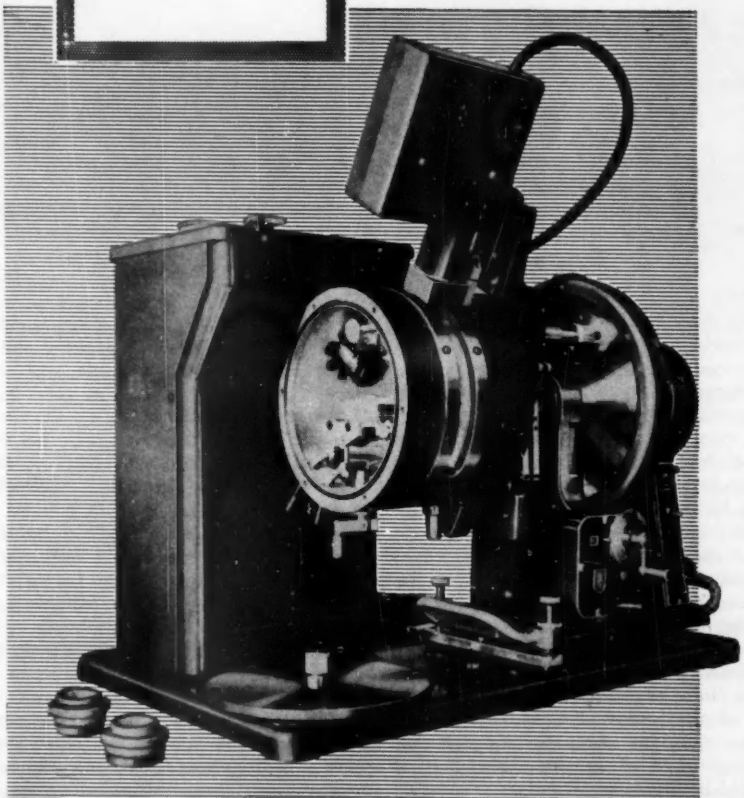

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ADVANCES IN ELECTRO-EROSION

MARC BRUMA

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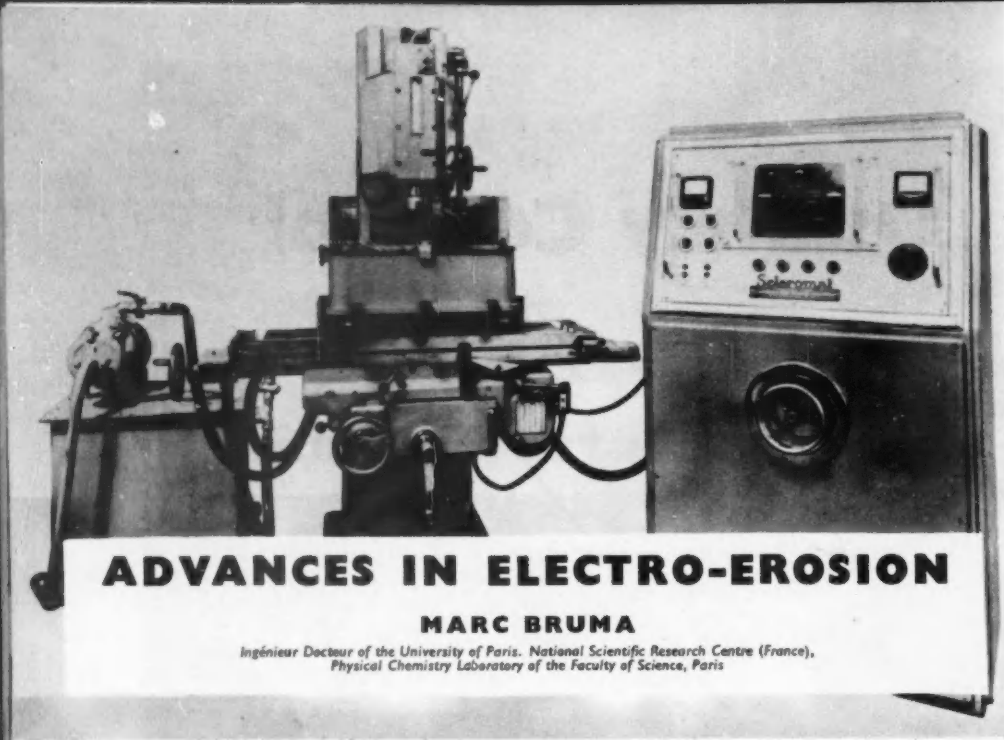


FIG. 1. Automatic electro-erosion machine.

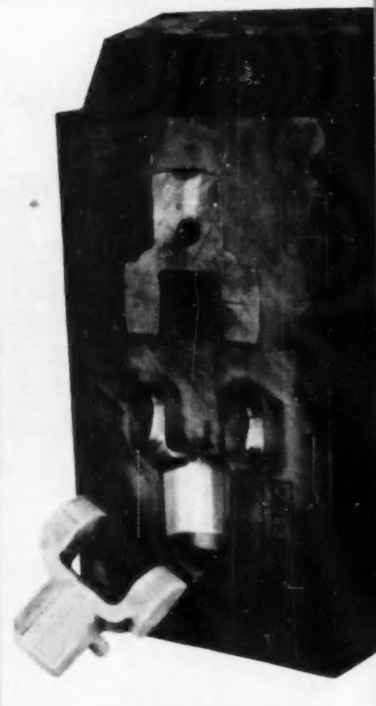


FIG. 2. **A hard-steel die and brass electrode.**

Electro-erosion, as a natural phenomenon, was discovered and described by the English scientist, Priestley, as early as the 18th century.

It is based on the fact that a sudden electric discharge (spark) between two charged electrodes is accompanied by removal of matter which affects the two electrodes unequally: under certain conditions it is possible to concentrate most of this erosion on the positive electrode.

It has also been established that by immersing the electrodes and making the discharges in a dielectric fluid the amount of matter removed per unit time is increased. The removed matter is found in the form of agglomerates of micro-shavings suspended in the fluid. Since the removal of anode matter takes place whatever the hardness of the metals or alloys forming the electrodes, it is possible to attack hardened steel and even tungsten carbide with an electrode made of copper, brass, or any other common alloy.

It is as if the cathode acted by multiple cutting-edges, each spark producing on the part to be machined the effect of a cutting-edge, and the total effect being an engraving of the relief and profile of the electrode on the part to be machined.

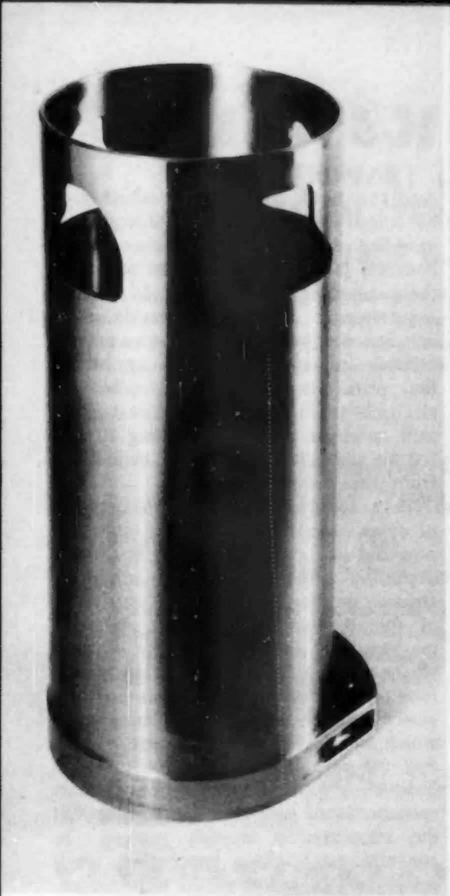
Thus we have at our disposal a tool with a potentially infinite number of cutting-edges, the dimensions of each being determined by a large number of parameters, including the intensity, duration, and frequency of repetition of the discharge, and the physical and chemical properties of the dielectric, work material, and electrode material. The mechanism of removal of material is not fully understood, but it is believed to be associated with the intense electrostatic field in the material around the point where the spark strikes the anode. It is hoped to obtain a better understanding of the process by scientific study and thereby to choose the values of the parameters to give the greatest rate of metal removal, consistent with a satisfactory product, particularly as regards surface finish. The rate of metal removal is necessarily much slower than for conventional machining methods and it is important that it should be increased as much as possible if electro-erosion is to become profitable in a wider field of industrial application.

ELECTRO-EROSION MACHINES

The main difficulty in the design of electro-erosion machines is the provision of a generator of electrical impulses of the required intensity and frequency. A variety of electrical circuits have been devised, but the majority are derived from one fundamental circuit. This consists of a capacitance or inductance to store electrical energy, which is charged over a relatively long period from a D.C. supply and discharged, over a relatively short period, between the electrode and the workpiece. The frequency of repetition of the sparks is determined by the time constant T of the charging circuit and the duration of a spark is determined by the time constant t of the discharge circuit. In practice T is many (10–1000) times t. It follows that the power used by the spark during the discharge is very much larger than the mean power fed to the machine. The provision of a suitable D.C. supply from the A.C. supply to the machine, is in itself a considerable problem of electrical technology.

Our own experiments, carried out in the laboratories of the Centre National de la Recherche Scientifique, show that there is still room for considerable improvement in the construction of spark generators of high power, frequency, and efficiency. It can be stated, however, that in the very near future it will be possible to increase appreciably the speed of machining by electro-erosion while at the same time improving surface rugosity.

Fig. 1 shows the complete equipment for automatic machining by electro-erosion developed as a result of studies by the Centre National de la Recherche Scientifique. This consists of a spark generator, a servo-operated electrode-tool, and a pressurised circulating system in closed circuit for the dielectric fluid.



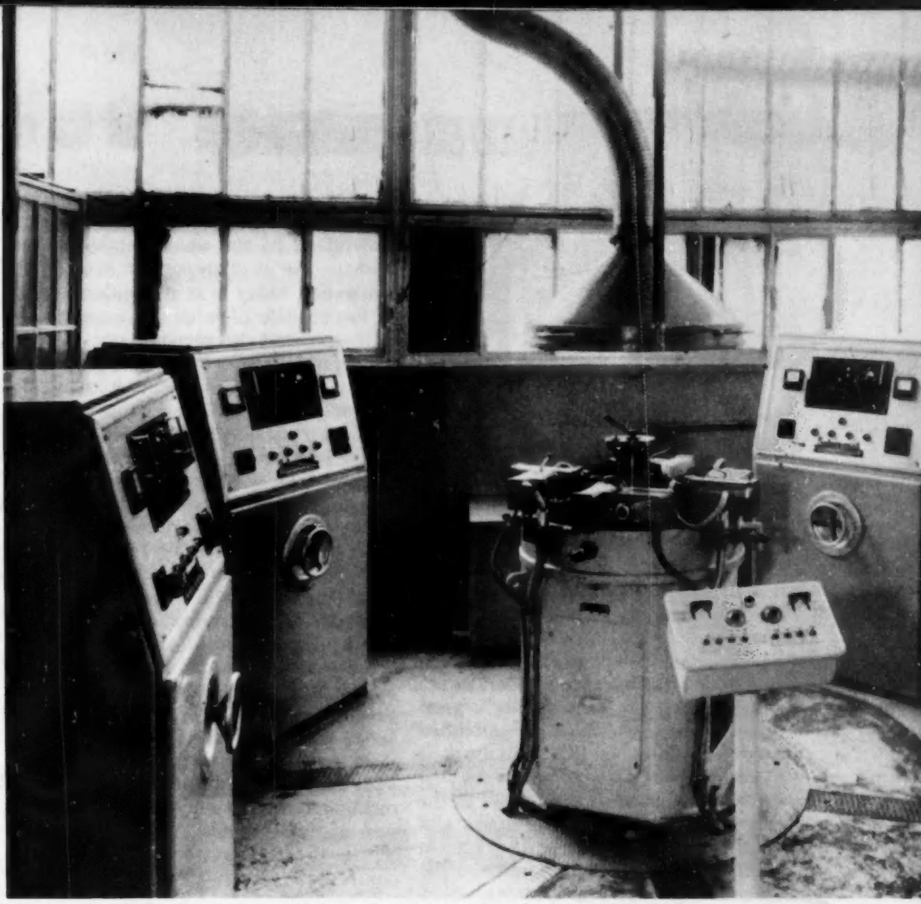


FIG. 3. Aircraft engine cylinder lining, previously hardened, into which the four inlet and outlet parts were cut by electro-erosion in ten minutes by the equipment shown in Fig. 4 on the right.

AUTOMATION AND ELECTRO-EROSION

Compared with conventional methods of machining, electro-erosion is far more versatile.

In fact, the introduction of the electron as a cutting tool, constitutes a revolution in that it permits an entirely new approach to problems set by the automation of mechanical manufacture.

These machines carry out complicated work automatically by breaking away from the need to restrict the instantaneous movement of the cutting-edge to information obtained from a feeler exploring a preliminary model. The model here is represented by the cathode, and the electron-tool explores its relief without any other intermediary and according to the laws of electrodynamics.

It is likewise unnecessary to programme the movement of the electrode or the part to be machined. The completely automatic working of electro-erosion machines is ensured by an apparatus which holds the spark-gap for the discharge constant, whatever the geometry of the electrodes and their movement in relation to the parts to be machined.

Naturally automatic, electro-erosion machines bring a new solution to the automatic machining of such equipment as dies for forging, cutting, stamping, and punching, moulds for pressure casting, drawing-plates, etc. They also possess the interesting property of avoiding the risk of subsequent deformation through thermal treatment, this being carried out before machining.

Fig. 2 shows a die (hard steel) and the electrode (brass) used.

It would be incorrect to assume that the field of application of electro-erosion machines is limited to the manufacture of tools. These machines provide a simple solution to many problems of production, and several recent achievements in France may be quoted in this connexion: one concerns equipment which makes blade sockets for turbines; another machines simultaneously the four ports (inlet and exhaust) of previously hardened cylinder liners for aero engines (Figs. 3 and 4). A third application at present being studied by atomic energy engineers is the automatic and telecontrolled cutting of radioactive uranium bars for nuclear reactors.

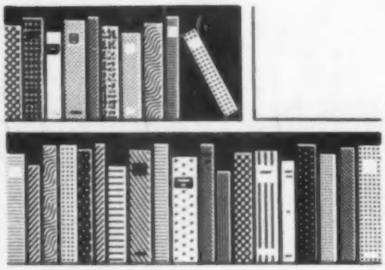
Electro-erosion machines, of complex shape, with revolving electrodes designed for sharpening and milling should also be mentioned.

It is now essential that a technology for the rational use of electro-erosion machines be elaborated, and this calls for a completely new outlook. This new technique will bring about a profound change in the attitude of mind of engineers, designers, and workshop operatives. It is not only a question of adapting electro-erosion machines to ordinary production processes, but also of freeing these from their own limitations.

In France, the Centre National de la Recherche Scientifique has undertaken the systematic study of electro-erosion and its industrial applications. These studies have revealed the relationship between the geometry of craters on the one hand and electrical and physiochemical factors on the other, thus permitting the determination of optimum conditions for generating sparks for machining by electro-erosion.

However, a great deal of experimental research work still has to be done before we can claim to have evolved a satisfactory theory of the electro-erosion effect.

[The Editor is grateful to A. C. Rapier for revising the original translation.]



THE BOOKSHELF

Science in the Development of Africa

By E. B. Worthington (*Prepared at the request of the Commission for Technical Co-operation in Africa South of the Sahara and the Scientific Council for Africa South of the Sahara, 1958*)

This encyclopaedic work is a testimony not only to the increasing amount of scientific research and its application carried on in Africa, but also to the growing scientific and technical co-operation that is taking place between its territories. A counterpart to Lord Hailey's great *African Survey*, of which he published the revised edition in 1957, this book is divided into four parts, of which the first deals with the general background to the changes now taking place in Africa and the place of science in them. It describes, with the usual plethora of initials, the large number of organisations, both national, regional, and international, which are now concerned with assisting the social, political, and economic development of Africa and makes some assessment of their adequacy. The second part deals in detail with the work going on in geographical survey, geology, meteorology, and in water supply and conservation, and soil survey and protection. The lateness in the development of scientific research in Africa is well illustrated by the fact that only in 1954 was the first major chain of first-order triangulation, the arc of the 30th meridian from the Cape to Cairo, completed.

The third part deals with the biological subjects, including agriculture and its associated technologies. It is in this field that the greatest immediate improvement in living standards can be made; but, although great advances in knowledge have been achieved in recent years, the scientific understanding of tropical agriculture has still a long way to go to catch up with that in the temperate zones. A serious difficulty, however, is the application of what is known in face of local conservatism, and Dr Worthington makes a plea for putting to greater use the findings of the social sciences; particularly in their exposure of the facts of tribal custom and social organisation: for instance, the place of livestock in native economy and custom. Land-holding is another even more troublesome political subject whose complications can only be understood by the social anthropologist. Perhaps the most important field of investigation today is in the understanding of the attitude of mind and reactions of different racial and social groups.

It is unfortunate that the original plan to deal with these and other human subjects was abandoned for a much shorter fourth part dealing with medicine and the social sciences in two chapters. Nevertheless, this contains some fascinating descriptions of recent archaeological discoveries; providing evidence not only of some of the ancestors of *Homo sapiens*, but also of ancient periods of localised artistic achievement and civilisation, separated by long periods of stagnation.

Now the territories of Africa are on the march and, under differing political forms, are likely to be, for many years, the scene of social and political upheaval. Scientists cannot solve the political conflicts, but they can help, not only in the fight against a frequently harsh environment, but also in uncovering the social and biological facts with which conservatism can be overcome and prejudice confronted.

A. ALBU

The Physical Basis for Electrical Engineering

By Thomas L. Martin (*Macmillan & Co. Ltd, 1958, xii+410 pp. Line illustrations. 8¼ × 5 in. 30s.*)

There has long been a need for a book of this kind. In spite of the fact that the basic concepts of the conduction of electricity through metals have by now been established for many years, the electrical engineering student is still generally confronted with a textbook which ignores any but the merest glance at these concepts, and starts by making the assumption that "an electric current is caused to flow through a conductor when an electromotive force is applied".

Prof. Martin (who states in the preface that the book is intended for engineers) deals first with electrostatic fields in vacuum and then with magnetic fields. He next touches on the extranuclear atomic structure, leading to the nuclear structure, which logically carries the reader on to the structure and behaviour of metals and semiconductors. He then shows the application of the concepts he has set out to gaseous conduction and thermionic valves, and to the use and application of insulators and capacitors.

It is strongly recommended that those concerned with the teaching of the early stages in electrical engineering should read this book and consider whether or not they would be wiser to introduce a modified and shortened version of its contents into the very earliest stages of their teaching, regardless of syllabus requirements. This suggestion is made because the book provides so comprehensive and sound a foundation of the first principles on which the whole of electrical engineering is built that it might well assist the student in making all that follows seem only to be logical deductions from these principles.

Take, for example, the whole question of conduction through metals, on which practical electrical engineering is entirely dependent. Prof. Martin, in an admirable chapter on the structure and behaviour of metals, sets out (without elaborate mathematical analysis) the basic physical reasons why it is possible to convey current through certain substances and not easily through others. The manner in which he conveys his argument is such that the path from the relatively simple conducting processes to the more difficult semiconductor phenomena is so easy that the transition is scarcely noticed. In conventional teaching approaches, semiconductors (now one of the most important aspects of electrical engineering) come in as a special subject, entirely removed from elementary theories of conducting metals, at a very late stage in a student's electrical education. With Prof. Martin's approach, the student learns at the earliest stages the intimate relationship between "normal" conduction processes and those applicable to semiconductors.

There seems to be scope, if the reviewer may venture to offer a suggestion to the author, for a more elementary edition of the book, because then it would become an ideal first-grade textbook, not only for those who are intending to become professional electrical engineers, but for the general student of science who wishes to obtain a basic knowledge of electrical phenomena.

The book is clearly and simply written and there is relatively little mathematics to halt the flow of the argument. The diagrams (although there are not as many as might be hoped for) are without exception clear and simple. There is rather an unexpected omission—a lack of reference to thermo-electric phenomena such as the Seebeck and Peltier Effects, which are becoming applied to an increasing degree at the present time. Apart from this, nothing is omitted that could help the student to gain the clearest possible appreciation of the physical basis for electrical engineering.

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GEOPHYSICS AND SPACE RESEARCH

By ANGELA CROOME

Antarctica—One or Two Continents?

More than fifty years ago, Griffith Taylor, geologist with Captain Scott's first Antarctic expedition, put forward the idea that east and west Antarctica were separated under the ice-cap by a trans-continental trough. This depression would connect the big indentations in the Antarctic coast, the Ross Sea, which pushes to within 300 miles of the Pole from the Pacific side, and the Weddell Sea in the Atlantic sector. These two seas point roughly towards each other across the main continental mass.

Griffith Taylor based his view on the geological as well as the geographical evidence. Western Antarctica is of a radically different geological structure and age from that of eastern Antarctica. The latter lying mostly east of the 0° to 180° meridian consists of a vast, elevated "shield" of pre-Cambrian rocks which are more than 500 million years old. This ancient "basement complex" is composed essentially of metamorphic rocks intruded by igneous rocks. These in turn are overlaid by younger, flat-lying sedimentary rocks. Western Antarctica on the other hand is characterised primarily by folded ranges and plateaux similar to those of the Andes and of which they are thought to be the extension. They are of much later date than the eastern Antarctic "shield".

The edge of eastern Antarctica, along the eastern border of the Ross Sea is known to be a *horst* region—a linear block of the earth's crust that has been uplifted along faults in the surface. The *horst* may well extend right across the continent to the Weddell Sea. Such structures are generally paralleled by down-dropped, trough-like blocks—*gräben*. A good example is the Rhine Valley.

Now seismic data gathered by the several American ice traverses that have been carried out or are now in progress point to the same conclusion. A traverse last year from Ellsworth station on the Weddell Sea detected a deep trough extending inland from the Filchner ice-shelf. The bottom was found to average almost 4000 ft. below sea-level. The trough appeared to continue south and westwards beyond the limits of the traverse, in other words towards the supposed position of the hypothetical trough beneath the Ross Sea.

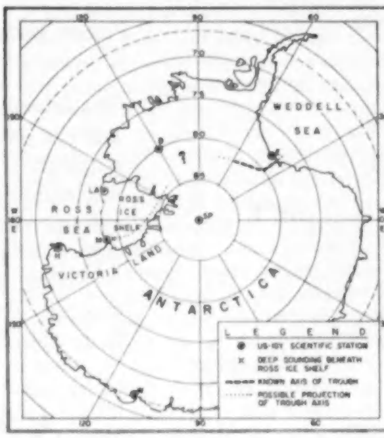


FIG. 1. Possible location of Hypothetical Antarctic Trough. U.S.-IGY Antarctic stations are Byrd (B), Little America (LA), Ellsworth (E), Wilkes (W), South Pole (SP), and the Naval Air Facility, McMurdo (M); the co-operative N.Z.-U.S. Hallett Station is designated (H).

Now news has just come in from the extensive ice-thickness survey currently being conducted between Little America station across the Ross ice-shelf and up into the Victoria Mountains to the east of Ross Island by Dr Albert P. Crary and his team, of an unprecedentedly deep sea-floor sounding beneath the ice-shelf near Ross Island. An ice-shelf traverse last season showed the bottom to average between 2070 and 2155 ft. below the Ross ice-shelf surface. The new seismic sounding, at 79° 06′ S, 165° 30′ E registered 4400 ft., double that of any previous sounding beneath the shelf. The position would be a logical one, in the opinion of the scientists making the traverse, for the Pacific extension of the transcontinental *gräben*.

One other piece of evidence tends to support the *gräben* idea. At approximately 80° 15′ S, 113° W, on the Marie Byrd plateau in western Antarctica a traverse party last year found the rock floor to lie at 14,000 ft. beneath the ice-cover which made it 8000 ft. below sea-level. This point may well be somewhere near the inland centre of the *gräben* if it does in fact connect Ross and Weddell Seas. The Americans are planning to carry out an airborne seismic and gravity survey around this area before the end of this season to try and establish conclusively whether Antarctica is split in half or not.

Further evidence should come from Wilkes station where a seismograph has now been installed at a point directly opposite the tip of South America across Antarctica. The path of an earthquake in this area must follow a trans-continental path to Wilkes. A study of such records should show whether the 'quake waves have passed through an island archipelago, a continent, or two continents separated by a trough.

A preliminary report has already come in (see *Nature*, January 31, 1959) from New Zealand scientists working on the seismic records in Antarctica of an earthquake on September 9, 1957. Their findings are that Antarctica is a continent.

Some Eclipse Results

The total eclipse of the Sun in the South Pacific on October 12 last year attracted more experiments than any previous such event. The final arbitrator of the occasion, however, was the weather. The period of totality for the Americans coincided with squalls and thunderstorms making all the optical experiments quite out of the question. The Japanese expedition seemed to be destined to the same fate, but at the last moment the storm-clouds opened for a few minutes and all was well. The British and New Zealanders, in contrast, had excellent conditions at their position to the West on Atafu.

But though the Americans were frustrated in making any visual observations of the Sun from the ground, their most striking and original experiment, that to be carried out above the atmosphere from rockets, was a complete success.

During a span of 38 minutes, five *Nike-Asp* rockets were launched from shipboard by scientists of the Naval Research Laboratory, led by Dr Herbert Friedman of the Electron Optics Division. Instruments in these rockets succeeded in mapping the Sun in wavelengths of x-rays and ultra-violet light from above the layer of interfering cloud. In recent years rocketry has contributed to our knowledge by revealing that powerful fluxes of extreme ultra-violet and x-radiation create the ionospheric layers of the high atmosphere.

But what has not yet become clear is whether the ultra-violet and x-ray emissions are concentrated in localised regions of the chromosphere or corona and how they are related to visible phenomena in the solar atmosphere.

Ionospheric soundings with pulses of radio-frequency waves have shown that the ionosphere does not disappear completely during eclipse totality. Is this due to the sluggishness of recombination processes or to a residual ionising flux capable of by-passing the eclipsing edge of the Moon? If there is such a residual flux coming from coronal heights in the solar atmosphere beyond the visible disc, is it composed of x-ray or ultra-violet radiations? These were some of the questions that the NRL rocket experiment on October 12 was designed to answer.

The rockets were equipped with detectors to measure x-rays in both the 8–18 Å and 44–60 Å wavelength bands, and Lyman-α emission of hydrogen in the ultra-violet at 1216 Å. The data was telemetered to receiving antennae mounted in the nozzles of 3-in. guns which could follow the flight of the rockets. The Lyman-α radiation appeared to follow the uneclipsed area of the disc very closely and almost disappeared a few seconds after the rockets entered totality. Measurements before second and third contacts (that is when the Sun's disc is totally obscured by the Moon) showed great limb-brightening in x-rays. The x-ray emission strongly resembled the kind of intensity distribution observed in radio decimeter wave measurements. Thus, the Sun appears to be ringed by a bright x-ray halo.

Only five rockets were fired on the day of the eclipse for the reason that the firing of the first four *Nike-Asps* had shaken loose the connecting plugs in the remaining two rockets. A delay of eight minutes took place while the fault was detected, and one of the team dashed up the rocket and reconnected. The timing of the fifth firing therefore more or less coincided with the scheduled launching of the sixth, so the remaining rocket was held for background firing. It was fired early in the morning of October 13, when in fact a class 2 solar flare was in progress, though the eclipse team was not aware of this at the time. The rocket reached peak altitude just after a maximum of sudden cosmic noise absorption was recorded by American shore-based experimenters. Excellent data was received which showed no significant variation in ultra-violet emission but a strong enhancement of the x-ray fluxes in both 8–18 Å and 44–60 Å wavebands.

We hope to publish before long the results of the other groups that were able to carry through successful experiments at the recent total eclipse.

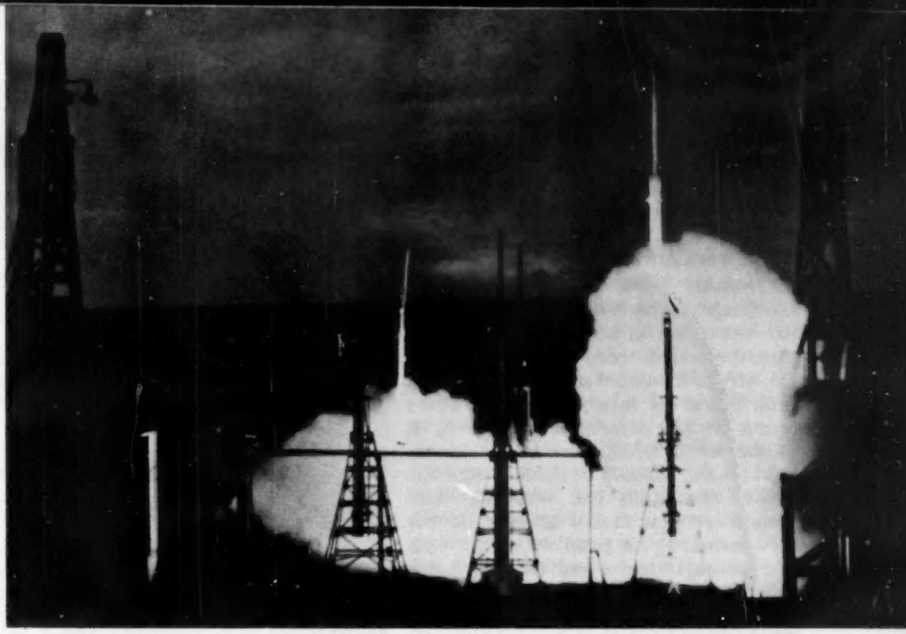


FIG. 2. Fourth shoot in eclipse sequence. Note the sky darkened by the eclipse.

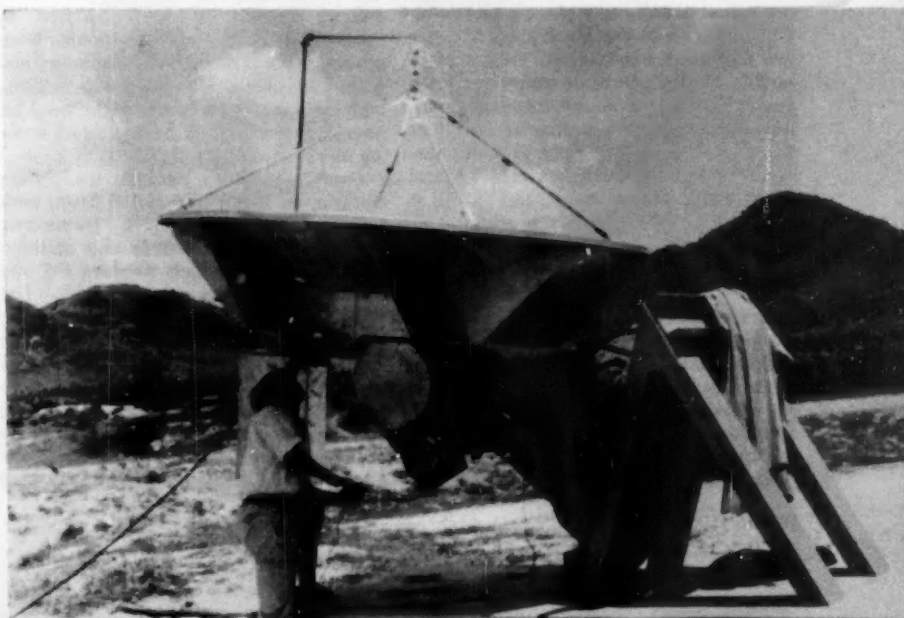
Russians Study Annular Eclipse

On April 19 last year an annular eclipse of the Sun was visible from the extreme south of China. (An annular eclipse is an eclipse where the relative sizes of the Sun and Moon's discs do not coincide so that a ring or annulus is visible round the occulting disc.) Russian radio-astronomers from Pulkovo took advantage of this opportunity to make some measurements of sunspots.

From observations of sunspots at centimetre wavelengths at Pulkovo Observatory, using the large radio-telescope (radius 100 m.) and polarisation telescopes, Soviet astronomers have concluded that bright, steady radio-emission regions exist above sunspots. They locate these in the solar corona at about 35,000 to 50,000 km. above the photosphere; their dimensions seem to correspond to that of the sunspot nucleus. Coronal condensation is thought to be responsible for the radiation.

Last year's annular eclipse visible from Hainan Island (18° N, 110° E) gave an opportunity to measure the temperature, magnetic field, and electron density associated with a large sunspot group then discernible on the solar disc. A joint expedition was mounted by the Soviet Academy of Sciences and the Academia Sinica. Three Pulkovo polarimeters were in use, those operating at 2 cm., 3·2 cm., and 5·1 cm. wavelengths. Measurements showed the magnetic field to be at least 360 gauss and the kinetic temperature

FIG. 3. Polarisation radio-telescope of 2 cm. in use on Hainan.



$(7\text{-}3) . 10^6$ degrees. The electron density is estimated to have been between 2 and $5 . 10^{10}/\text{cm.}^3$, though this is tentative, as the thickness of the emitting region is not known.

The *Lunik*'s Achievements

On January 2 the Russians launched a multistage rocket which passed close to the Moon, but as it was travelling faster than the critical speed necessary to orbit the Moon, it in fact continued and is in orbit round the Sun. Thirty-three hours later, at 5.59 a.m. on January 4, it passed within 3700 miles of the Moon. At 10 a.m., January 5, contact with the rocket was finally lost when its radio became so weak that it could no longer be detected; at this point the rocket flight had lasted 62 hours and the *Lunik* was estimated by the Russians to be 370,000 miles from the Earth. On January 7 it was estimated to have taken up a slightly elliptical solar orbit lying for the most part just outside that of the Earth but very nearly in the same plane and estimated to take 450 days to complete. On January 14 the *Lunik* was at perihelion, its nearest point to the Sun during its 450-day orbit; it is expected to be at aphelion some time in September of this year. Perihelion is estimated at about 91 million miles from the Sun, and aphelion 106,700,000 miles.

It is, however, highly improbable that the rocket will ever be observed again since its small size as a celestial object gives it insufficient brightness. There is some chance that it might collide with the Earth in the year 2113, when, it has been computed, there will be a coincidence of the Earth's position with that at the time of the *Lunik*'s launching and the time the *Lunik* passes this point in its 450-day orbit.

The total all-up weight of the rocket's last stage (when all the fuel was burned), the actual *Lunik*, is 1 ton 8 cwt 102 lb. (1472 kg.), the instrumental payload being 796 lb. Nine experiments were carried out, no less than three of which were concerned with cosmic-ray measurements. The experiments were: the detection of the Earth's magnetic field at great distances from the Earth's surface (several Earth radii) and of the Moon's field, if any; study of the intensity of cosmic rays and the variations of this intensity beyond the influence of the Earth's magnetic field; measurement of photons in cosmic radiation; the distribution of heavy nuclei in cosmic radiation; measurement of radioactivity associated with the Moon; study of the gaseous components in interplanetary matter; measurement of solar corpuscular radiation; measurements of meteoric particles.

International Geophysical Cooperation 1959 Final Calendar

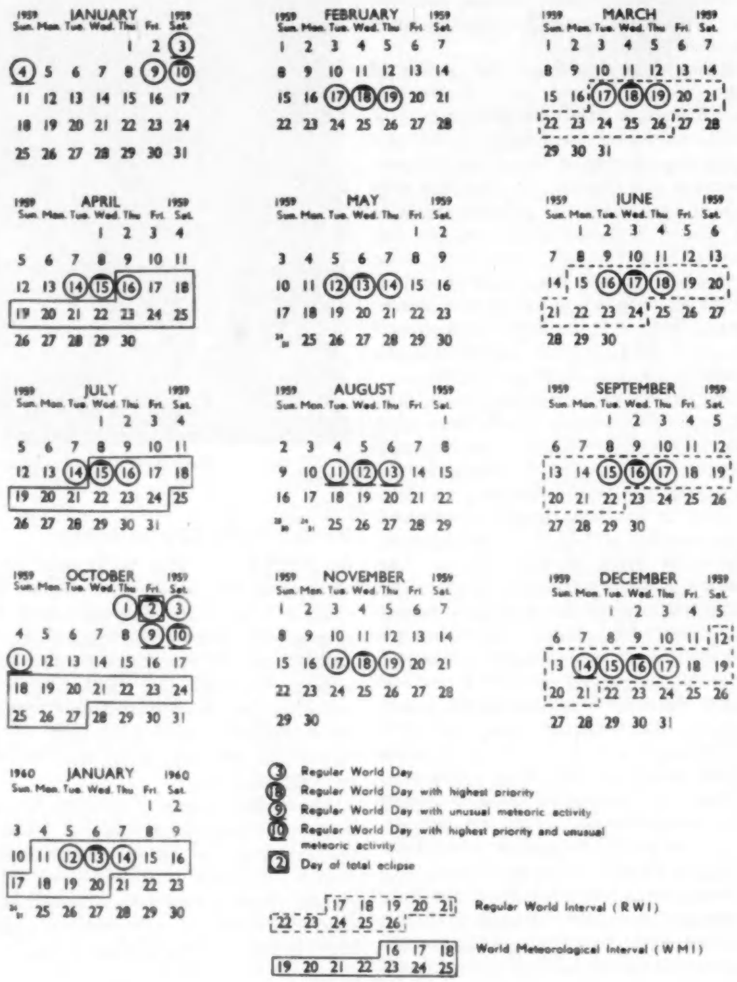


FIG. 4.

The three cosmic-ray experiments are directly related to those carried in *Sputnik III* and have no doubt been devised to expand the information gained from this vehicle. The other experiments, with the possible exception of the work on interplanetary gas, all have a direct bearing on manned space flight.

Four transmitters were carried. Those working on 19·997 and 19·995 Mc/s were for tracking purposes; a transmitter operating on 19·993 Mc/s and emitting beats varying in length between 0·5 and 0·9 second, relayed scientific data. The fourth transmission, on 183·6 Mc/s, passed on data relating to the rocket's relative motion and, apparently, other scientific information.

In addition to the radio-tracking arrangements, the *Lunik* was equipped to produce a luminescent sodium cloud for a brief period, and good visual fixes were obtained by the Russians on the night of January 3. From 1 p.m. on January 3 until some unspecified time on January 4 the *Lunik*'s radio signals could not be monitored as it was below the radio horizon of the Earth itself. As no advance notice was given of the rocket's launching, the tracking of the *Lunik* and the orbital elements derived from these have been entirely conducted by the Russians. The launching date must have been known well in advance, however, since a special stamp issue portraying the *Lunik* was on sale on January 3.

Speeds. Maximum speed attained during launching: 11·2 km./sec. (more than 7 miles/sec). Estimated speed at closest approach to Moon, 2·45 km./sec. At perihelion its estimated speed is given as 32 km./sec. or 19·8 miles/sec.; at aphelion, 27·75 km./sec. or 17·4 miles/sec.

SCIENCE ON THE SCREEN

Filmstrip brings Psychology to Foremen

The Centre de Synthèse, a firm of Management Consultants in Paris, has run thousands of courses for supervisors on "How to Observe and Know Men". They work on the theory, which seems acceptable to the logical Gallic mind, that the techniques of understanding workers are as important as any other production skill. These courses have been run not only throughout France but in Belgium, Luxembourg, Italy, and even for the Industrial Welfare Society in the United Kingdom.

Getting foremen to study human behaviour and trying to persuade them to apply this knowledge to their jobs, sounds a little strange to most Englishmen. The French, on the other hand, regard psychology as a subject for everyone. So the Centre has developed a series of courses, which teach, through directed discussion groups, how a planned observation of their subordinates and colleagues can produce greater co-operation and higher productivity.

Every session is based on the use of sound filmstrips. These are simple, even over-simplified case histories. The characters are primitive line cartoons, the dialogue is in down-to-earth argot. It is at times frankly crude. Yet these strips are used, and used until they become scratched and worn out. They alone have provided the livelihood for a team of consultants for over seven years.

This use of a static audio-visual aid with tough adult audiences is so interesting that I think it should be considered in some detail.

The giving of orders, criticism, praise, and reprimand, are of tremendous importance in the complex structure of modern industry. These necessary skills of management can be made more effective and easier, if supervisors can be taught to develop a scientific and rational method of dealing with workers. Much strife is caused, not so much by changing work methods and automation, but by the way in which all levels of management explain the situation.

French logic applied to problems of communication and human relations has produced a course which certainly sells. Pierre Gourgand, the Secretary-General of the Centre, tells me that the French company of a large International Group has arranged courses for its staff for twenty-five consecutive weeks in 1959.

I sat in on some of their sessions and saw how these simple cartoon strips are used in small conference rooms in factories, with groups of six to ten people. The foremen sit on either side of a long table with a group leader at one end. In front of him he has a filmstrip projector and a tape recorder. Behind him a pad of newsprint paper on an easel and a flannel board. After a short introduction he projects on to a screen at the other end of the table a two- or three-minute incident with the dialogue in contrasted regional voices. The sketch, which is very carefully worked out, gives an example of bad handling of workers.

He then asks the group to tell him what they have noticed and he writes up a list of the observations made by the participants. He tries to get the group to tell him how the foreman said "Good morning": how he broached the subject of the interview, and how he coped with the problem. Sometimes they do not get all the implications of the interview. So he runs back the tape recorder to the start of the dialogue. To help him do this the filmstrip is marked in coloured chinagraph and the tape recorder has a time dial and he works from a prepared chart. The participants then see and hear it again. After this second viewing they begin to develop a sense of observation. The object of the exercise becomes clearer, and they fill in the gaps in their previous observations.

Left and below: Examples from the French filmstrips used to train foremen.

The names of the characters indicate their personality: there is Lamb, and Bull, Lord, and Sergeant. As the foremen see and discuss case history after case history it becomes clear to them that the approach to a dependent character like Lamb is

entirely different from that suitable to a dominant Bull.

As the foremen become drawn into the "game", they become more interested and co-operative. Quite soon they give every sign of having forgotten that the film-strip represents artificial situations with sketchy drawings. They seem to associate their own problems with the screen images. The discussions become more lively and more personal.

All the way through discussions are summarised on the large sheets of paper, which are turned over when completed. They can be flipped back again if the leader wants to refer to what has happened. In the same way he can run back the filmstrip and the tape in a few seconds to any of the previous sequences, if discussion makes a comparison desirable.

It is difficult to say how effective this type of simple practical applied psychology is. The courses are planned in collaboration with trained psychologists and have been demonstrated at the Sorbonne. The proof of their value would seem to be that the Centre de Synthèse continues to run courses and train instructors from firms. They also supply them with kits containing filmstrips, tapes, manuals, and flannel board material to sum up major points.

One example of the type of concept that they try to get foremen to accept is built up on the flannel board.

> "Every stimulus that we apply to a subordinate must be related to his personal needs. If the stimulus is planned to coincide with his needs to have, to do, to be and to love or be loved, the results will be positive motivation. This leads automatically to a change of attitude. If the stimulus runs contrary to the man's needs, the motivation will be negative, and the result, frustration."

As frustration is the major occupational disease in every sphere of modern life, if filmstrips can help supervisors to minimise negative reactions, they will be doing a very useful job. I am convinced that these courses, with their large amount of audience participation, are good; even if they cannot produce a nation of foremen-psychologists. L. GOULD-MARKS

This is a view from the inside of the human heart looking out through the mitral valve "chordae tendinae" which act much like the shroud lines of a parachute in keeping the leaves of valves in their proper position when closed. When open, these cords lie relaxed along the wall of the heart. This photograph is from the film, *Red River of Life*.

Red River of Life

An interesting film on the blood-supply system of the human body which is distinguished by some brilliant photography and a fascinating sequence demonstrating the function of the human heart.

The film, which is in colour, opens with a description of the arteries and veins and the capillaries which link them. Pictures then show the mitral and aortic valves opening and closing during the beating of the heart, together with an operation on the heart, during which a heart-lung machine is used, as a plastic valve is inserted to replace one damaged by disease.

The film then concentrates upon the nature and function of the blood itself. The speed of absorption into the bloodstream and the velocity of the stream itself are demonstrated by following, with a Geiger counter, radioactive iodine particles swallowed in a capsule by the narrator. Excellent pictorial quality, an informative commentary, and the use of descriptive analogies make the subject easy for the layman to understand.

Entitled *Red River of Life* and having a duration of 75 minutes, this film may be had on loan from Fact and Faith Films, Falcon Court, 32 Fleet Street, London, E.C.4. No charge is made to school and college audiences. G. DAVIS

Visual Aids Officer for British Association

Alec M. Hughes has been appointed Visual Aids Officer of the British Association for the Advancement of Science and took up his new duties on November 1. From February 1955 he was General Secretary of the Scientific Film Association, having previously for seven years been Deputy Warden and Senior Lecturer at Burton Manor Residential College for Adult Education.

Mr Hughes's appointment is part of the ambitious development programme of the British Association, made possible by the generous support of industry, and designed not only to facilitate a better

exchange of information among scientists but also to create a public opinion better informed about the contribution of science and technology to everyday life. The Annual Meeting, to be held this year in York from September 2 to 9, will include exhibitions of scientific films, first introduced as a separate feature of the programme at Bristol in 1954. Area committees, some already established, others in the process of formation, will enable the BA to operate continuously on a nation-wide scale and visual aids will play an important part in these activities.

Of particular significance is the educational programme for young people designed to interest them in science, either as eager participants in scientific development or as informed laymen. Junior BA meetings will develop an idea first tried experimentally at Glasgow in 1958, and these also will include the use of films and other visual aids.

The BA is acutely aware of the significance of television for presenting science to millions and hopes to encourage not only special programmes by eminent scientists but also to play a major part in interesting a much wider body of experts in the effective use of this medium.

These developments are to be welcomed enthusiastically, for the BA has a most important job to do. Enjoying as it does the respect and support of science and industry, no body is better fitted to coordinate the work of the many agencies concerned with presenting science visually; to spotlight deficiencies and to suggest new subjects for visual treatment; and to bring together sponsors, producers, and scientists to aid visually in the advancement of science.

Television Science for Adults

Judging from the style of science broadcasting which we have now experienced for some considerable time, the pattern of the programmes on BBC seems by now to have crystallized out into two related but quite distinct formats. On the one hand have been the regular half-hour outside-broadcast visits, very often to large national research establishments such as the National Physical Laboratory, the Royal Aircraft Establishment, Atomic Energy stations and so on. The "Eye on Research" programmes produced by A. Singer belong to this category. The aim seems to have been that of bringing to us some idea of the formidably massive researches and long-term projects going on in this country. Many of the broadcasts were thus inevitably concerned with researches directly sponsored by the Government. There were some notable exceptions in which University work predominated, but the general impression left, after some time, was that of visits to large laboratories, with researches conducted on an imposing scale.

The other parallel type of broadcast we have had, J. McCloy's "Science is News" is a different affair altogether. As implied in its title, this is a magazine programme which fortnightly seeks to focus attention on current items of scientific news. The programme usually consists essentially of three totally unrelated ten-minute items. Judged purely as a reporting magazine, and surprisingly enough, this programme has always succeeded, twice a month, in finding at least one item which is, to use press jargon, "hot news". This is perhaps some indication of the intense scientific activity in this country, for the material is always drawn from British researches and is not in this sense international. The remaining items which complete the news programme are at times extracted from what are in fact long-term current investigations. They are always put out with a certain air of tension, which heightens their news interest, but we certainly have no quarrel with this method of presentation; on the contrary we endorse it warmly. For every experienced teacher knows that the best way to teach is to invest a subject with emotional tone. Since the programmes are indubitably educative and since they often contain material difficult for the layman to absorb, any device to heighten interest is undoubtedly justified, provided there is no sacrifice in veracity. As the programmes have almost invariably involved an interview with an accepted authority, the accuracy of the material is unquestioned, so that the slightly theatrical approach used at times does no harm.

Now that these two programme types appear to have set hard, the time seems to have arrived where changes in approach might well be discussed. It is, of course, fairly easy to excite popular interest by a visit to a very large national research establishment. Who indeed would not be awed by a vast nuclear reactor or a massive supersonic wind-tunnel, an enormous ship-testing tank or a mighty space rocket? The producer hardly needs to exert his skill, the formidable subject does all that is needed for him.

One can expect a producer to take up a firmer challenge than that; and I have no doubt that producers could easily meet a firmer challenge. A great deal of the research in this country (perhaps the major amount in terms of man-power involved) is carried out in much smaller institutions than the great national establishments. There is an extensive field of exploration here for a producer's imagination. Let me suggest a policy in this connexion. Let television try to invest with the interest they deserve the innumerable research projects which bear intimately on our daily lives at almost every turn. It will surprise the viewer to learn that what he considers a most ordinary product has often years of elaborate research behind it and that current research is actively improving it at the moment too.

Let the camera pay a series of visits to the many smaller research establishments concerned with familiar objects, rather than to remote fields like atomic energy. Numerous examples come readily to mind. When we pass through a food store we are surrounded by canned products and a visit to the Tin Research Institute would open up the eyes of people to the extensive detailed researches going on to improve food cans. And they would be surprised to find that the stability of the shape of their pewter teapot, and the colours of their plastic lamp-shades depend also upon properties of tin all being actively studied. Or again, which mother has not wailed at the wear and tear of her children's shoes? A visit to the Leather Research Association might help us in this connexion. And there is the Paint Research Laboratory, and PATRA, the Printing, Packaging and Allied Trades Research Association, they could tell us a lot about ordinary things like cartons and wrappers and so on.

But this by no means exhausts the field of everyday materials. The Research Associations could be followed up by individual and specific industries. I have found a visit to a sugar refinery a scientific education in itself, and so would anyone else. Then there are petrol additives, hurled at us on newspaper, screen, and hoarding. A visit to a petroleum research laboratory would interest millions, if objectively carried through. The list is endless. A large catering organisation established in its research laboratory the relative absorption of different oils by different potatoes in the manufacture of chips and thereby effected a considerable economy. An item like this would make every housewife sit up and take notice. With all such popular items can be made very serious research programmes and I commend them to the producers.

One kind of broadcast has not had serious consideration on television, namely a prolonged course extending over a long period. The nearest approach to this were the six successive lecture-broadcasts on the Darwin Centenary. These were very successful and it may not be too much to ask for a prolonged scientific course, say a fifteen-minute broadcast every week for three months. Such a course, on the internal combustion engine, or on domestic machinery, for example, treated in both cases from a scientific and a practical angle, might repay consideration.

S. TOLANSKY

FAR AND NEAR

Estimates of Resources Devoted to Scientific and Engineering Research and Development in British Manufacturing Industry, 1955

This report of the DSIR, published on January 5, had a "preview" in a paper read by Mr E. Rudd to the British Association in 1956; this in part fuller report, however, acquires added significance in that it "represents the considered views of the Economics Committee of the Council for Scientific and Industrial Research".

An essential method for exploring this hitherto uncharted area was two field inquiries carried out by the Social Survey, one jointly on behalf of the DSIR and the Ministry of Labour into employment on research in private industry, and the second on behalf of the DSIR into expenditure from those firms who, having answered the manpower questionnaire, and having available records of their research expenditure, were willing to supply this data also. There was a parallel survey undertaken by the British Iron and Steel Federation among its members. The data was supplemented by other information relating notably to research outlay in Government departments, all of which combines to give a comprehensive picture of national research expenditure.

While about 85% of the establishments approached supplied information for the manpower sample, response to the expenditure inquiry was lower, and the resultant sample was in the strict sense composed of "volunteers". Nevertheless, the calculation from the latter inquiry of outlay per person employed is believed to be sufficiently reliable for estimates to be made of research expenditure overall and by types of industry. A further qualification—the definition of research was rather strictly drawn and may, notably in some older industries, such as ship-building, exclude certain outlay of a research character.

Of special interest among the findings are such facts as these: 75% of research expenditure by private industry is in three sectors—aircraft (nearly a half), electrical engineering, and chemicals; nearly 30% of the labour force in research is employed part-time; over half the manpower in research is in firms employing over 1000, while 58 companies or groups account for one-third of the research expenditure; the cost of research is (surprisingly) cheap—£1300 per person employed thereon; research outlay accounts for 3·5% of the net output of manufacturing industry—only in aircraft is it a high figure (35%), while in many industries it is less than 1%.

Though such figures permit useful deductions, it is regrettable that the analysis could not be extended to suggest, particularly to the layman, the *profitability* of research. Granted that defence research, accounting for £118 million of the £183 million of private industry's total research outlay, could not be separated out in the returns by contributing firms, there could still be valuable possibilities from analysing research outlay in relation to such factors as rate of growth, net output per person employed, export or import content. It is accordingly to be hoped that one result of this inquiry will be to encourage further official studies of this nature, not least, perhaps, a serious attempt to include questions on research within the orbit of future Censuses of Production.

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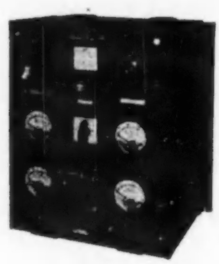

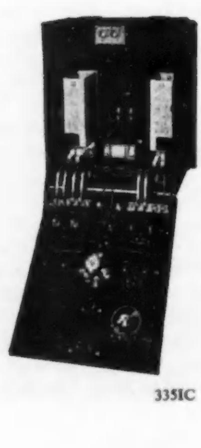

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efficiently if it is embodied in a microscope such as Darwin used for all his researches, having a simple focusing device and an object-holder.

At a cost of a few pence the amateur can with a little ingenuity make himself an efficient and very portable simple microscope by making a Chinese copy of the so-called "Compass Microscope" of the 18th century. The instrument described below cost about 4*d.* and packs away into a cigarette tin, taking no more space in the pocket than a cigarette case.

The basis of it is a draughtsman's compass of the pattern in which the legs are kept apart by a spring and closed up by turning a screw. This provides the focusing mechanism. The lens should be fixed in a holder of plywood or soft wire which can be gripped in the pencil-holder of the compass. With a little ingenuity various forms of object-holder can be devised to be fixed to the pointed leg of the compass, or the latter can be fixed in the side of a block of wood which is then used as the object stage (see Fig. 1). If a higher power is wanted than is given by the ordinary pocket lens, search must be made through the second-hand optician's stock for the dissecting lenses of the past century. Very good examples of these can often be discovered cheaply. The high power of the author's own instrument is an Andrew Ross dissecting lens of 40× power which was obtained for a few shillings from the junk-box of a friendly optician.

[*This valuable suggestion comes from Mr L. G. Lowry of Haywards Heath.*]

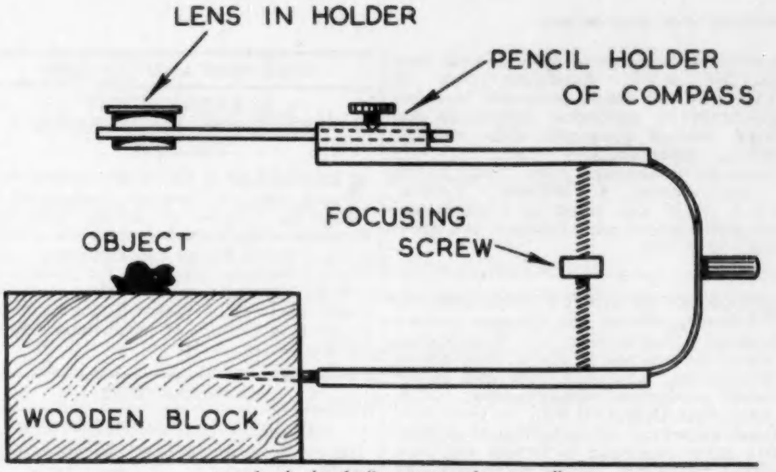

FIG. 1. A simple "compass microscope".

FIG. 2. Dr Ronald Hingley, University Lecturer in Russian at Oxford, with a sample group of students listening to a dummy run of the BBC's Lessons in Russian, which he will start on Network Three in October 1959.

(*BBC copyright photograph*)

Russian Lessons to be Broadcast

In October 1959 the BBC's Network Three will start a series of programmes teaching Russian. The series will be for absolute beginners and will begin with the teaching of the Russian alphabet.

The scripts will be written by Dr Ronald Hingley, Lecturer in Russian at Oxford University, and the lessons will centre round an eccentric professor called Sidorov. In the early stages the lessons will make full use of the element of sound for the purpose of identification; for example, Prof. Sidorov's telephone or a car horn in the street. Also, the first programmes will include a high proportion of recognisable words such as *telefon, sputnik,* and *komissar.* Pronunciation instructions will be based on such names as Tolstoy, Dostoyevsky, and Pushkin.

The series, which will be produced by Raymond Escoffey, will last a year and the programmes will be broadcast weekly (with repeats). There will be an accompanying handbook which will be on sale shortly before the series starts.

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